

Current Development Status of China's Eucalyptus Industry and Its Impact Analysis on Carbon Peak and Carbon Neutrality

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Abstract: As one of the three fastest-growing plantation tree species globally, eucalyptus plays a significant role in southern China's forestry economy and ecological construction. To clarify the development trend of the eucalyptus industry and its positioning in the "dual carbon" goals, this paper systematically analyzes the planting pattern, industrial chain characteristics, and strategy environment of China's eucalyptus industry based on the latest industry data and research findings from 2024 to 2025. It examines the dual impact of eucalyptus on carbon peak and carbon neutrality from three dimensions: carbon sequestration capacity, emission reduction substitution, and ecological cost, and proposes sustainable development pathways. The study shows that China's eucalyptus plantation area reached 6.0888 million hectares in 2024, with Guangxi accounting for 50.7%. Through ecological forest management technology upgrades, it is possible to achieve synergistic improvement in wood production and carbon sequestration capacity, thereby enhancing soil carbon storage. The research suggests that the eucalyptus industry can become a crucial supporting force for achieving the dual carbon goals through a three-dimensional approach of "technological innovation + model optimization + market-driven."

Keywords: Eucalyptus Industry; Carbon Peak; Carbon Neutrality; Carbon Sequestration Capacity; Ecological Forest Management

1. Introduction

Against the backdrop of global climate change, achieving carbon peaking and carbon neutrality has become a core issue for sustainable development worldwide. As a crucial carrier of carbon pools, forestry has attracted significant attention for its potential in carbon sequestration and enhancement. In the context of the "Dual

Carbon" goals, the implementation of domestic emission reduction efforts is essential to accomplish carbon neutrality as early as possible. Compared with industrial emission reduction, forest carbon sequestration is more cost-effective [1-4].

Eucalyptus, renowned for its fast growth rate, short rotation period, and high biomass accumulation efficiency, has been listed by the Food and Agriculture Organization (FAO) of the United Nations as a key fast-growing and high-yield tree species for global promotion. Since its introduction to China in 1890, a large-scale industrial system has been established. As of 2024, the area of Eucalyptus plantations in China ranks second globally. While ensuring wood security, the carbon sequestration function and ecological effects of Eucalyptus have sparked extensive discussions. Currently, the Eucalyptus industry faces a development dilemma characterized by "prominent economic value coexisting with ecological controversies." The adaptability of traditional management models to the Dual Carbon Goals urgently needs to be clarified. By analyzing the current development status of the Eucalyptus industry, quantifying its carbon sequestration capacity and carbon emission intensity, and identifying key influencing factors, this study provides a theoretical basis for constructing an Eucalyptus industry development model that synergizes "ecology-economy-carbon sequestration," which holds practical significance for promoting the green and low-carbon transformation of forestry.

2. Current Development Status of China's Eucalyptus Industry

2.1 Planting Pattern: Regional Concentration and Steady Scale Expansion

Eucalyptus planting in China exhibits a distinct feature of regional agglomeration. In 2024, the planting area reached 6.0888 million hectares, among which the Guangxi Zhuang Autonomous

Region ranked first in the country with 3.087 million hectares (accounting for 50.7%, equivalent to 46 million mu), and its log output reached 26.791 million cubic meters [5].

2.2 Strategy Environment: Development Orientation with Both Regulation and Support

At the national level, the commercial forest attribute of Eucalyptus plantations has been clarified through classified management policies, while ecological constraints have been strengthened. At the local level, represented by Guangxi, the Implementation Plan for Further Deepening the Pilot Reform of Eucalyptus Artificial Commercial Forest Harvest Management was issued in 2025 to promote large-scale and intensive management, and Eucalyptus was listed as one of the first priority tree species for carbon sink afforestation [6].

3. Dual Impacts of the Eucalyptus Industry on Carbon Peaking and Carbon Neutrality

3.1 Positive Driving Effects: Dual Contributions of Carbon Sink Growth and Emission Reduction Substitution

3.1.1 Efficient carbon sequestration significantly enhances ecosystem carbon sequestration capacity

Owing to its fast growth, Eucalyptus possesses strong carbon capture capabilities. As a fast-growing tree species, it has high photosynthetic efficiency and can directly increase carbon absorption by expanding the planting area [7]. The annual carbon sequestration of Eucalyptus forests in Guangxi reaches 33.02 million tons, and the optimal stands can sequester 16 tons of carbon per hectare annually—8 times the national average level (2 tons per hectare per year) of major afforestation tree species [8].

Carbon sequestration capacity increases in stages with stand age: the soil carbon storage of 12-year-old Eucalyptus urophylla stands reaches 136.86 tons per hectare, an 89.5% increase compared to 7-year-old stands; the soil carbon storage of 20-year-old Eucalyptus citriodora stands increases by 85.7% compared to 3-year-old stands, with a significant carbon accumulation effect in deep soil (60-100 cm) [9].

Carbon sequestration potential can be further expanded through technological optimization:

the carbon storage of Eucalyptus forest ecosystems using the "no slash-and-burn + mechanical strip cultivation" site preparation model reaches 197.03 tons per hectare, a 36% increase compared to the traditional slash-and-burn model [10]; when Eucalyptus is mixed with native tree species such as *Castanopsis hystrix* and *Parashorea chinensis*, carbon storage can be increased by 13.9% - 14.9 % [11].

3.1.2 Biomass substitution effect reduces dependence on fossil energy

As a high-quality renewable resource, Eucalyptus demonstrates prominent substitution value in the energy sector. Its woody fibers can be efficiently converted into fuel for biomass power generation: 1 ton of Eucalyptus biomass used for power generation can replace 0.5 tons of standard coal and reduce carbon dioxide emissions by 1.3 tons [11]. Guangxi has established multiple integrated "Eucalyptus-biomass energy" projects, processing 2 million tons of Eucalyptus residues annually and achieving a reduction of 2.6 million tons of carbon dioxide equivalent [9].

In addition, promoting long rotation periods of 7-8 years and low-density planting (100 trees per mu) to cultivate large-diameter timber can reduce carbon emissions per unit of wood, improve economic benefits, and mitigate ecological impacts [12]. As an industrial raw material for pulp and wood-based panels, Eucalyptus wood can replace approximately 30 million cubic meters of natural wood harvesting annually, indirectly reducing carbon emissions caused by natural forest destruction [11].

3.2 Potential Negative Impacts: Carbon Leakage and Ecological Risks of Traditional Management Models

3.2.1 Intensive management leads to carbon emissions and carbon pool loss

Traditional short-cycle pure forest management faces significant carbon loss issues: the soil organic carbon of Eucalyptus forests under 6 consecutive rotations decreases by 16.12%, while total nitrogen and total phosphorus decrease by 31.42% and 41.17% respectively, impairing the stability of soil carbon pools [13]. Direct carbon emissions occur during the management process: carbon emissions from fuel consumption of logging machinery are approximately 0.05 tons per cubic meter of logs; indirect carbon emissions from excessive

chemical fertilizer application account for 42% of total emissions during the forest management stage; and traditional residue incineration releases large amounts of carbon dioxide [9].

Studies by Li Peiyue et al. have shown that carbon emissions during the production and management of Eucalyptus plantations can be significantly reduced through refined management of energy and fertilizer use, adoption of clean energy, and optimization of transportation methods [14].

3.2.2 Ecosystem degradation weakens long-term carbon sink stability

The single-species pure forest model has led to a sharp decline in biodiversity. Monitoring data from over 500 sample plots in Guangxi show that compared with the 1st-generation Eucalyptus pure forest, the understory plant species richness of the 6th-generation Eucalyptus pure forest has decreased by 70%, and the Shannon-Wiener diversity index has dropped by more than 90%. This weakens the ecosystem's resistance to disturbances, making its carbon sequestration function prone to fluctuations affected by diseases, pests, and extreme climates. Meanwhile, soil erosion caused by traditional forest management will further reduce carbon pool storage.

4 Main Challenges of the Eucalyptus Industry in Adapting to the Dual Carbon Goals

4.1 Ecological Controversies Restrict the Sustainable Development of the Industry

Misconceptions such as "Eucalyptus depletes water and nutrients" and "Eucalyptus damages the ecology" are still widespread. Some regions have introduced policies restricting Eucalyptus planting; for instance, new Eucalyptus cultivation is prohibited in some water source protection areas in Guangxi, which limits the space for carbon sink forest construction. Although scientific research has proven that ecological forest management models can address soil fertility decline (e.g., bag-controlled slow-release fertilizer technology reduces nutrient loss by 51.5%), the promotion rate of such technologies is only 35%, and traditional management models still dominate [9].

4.2 Imperfections in Carbon Sink Accounting and Trading Mechanisms

There is no unified standard for Eucalyptus carbon sink measurement. Different monitoring

methods (eddy covariance method, sample plot survey method) adopted in various studies lead to significant data discrepancies. The current CCER (China Certified Emission Reduction) methodology has ambiguous definitions for carbon sink accounting of Eucalyptus mixed forests and coppice forests; approximately 40% of Eucalyptus plantations cannot be included in carbon trading due to failure to meet measurement standards [11]. Additionally, the carbon pricing mechanism is immature: the domestic carbon price (about 60 yuan/ton) is lower than the international level, making it difficult to fully motivate managers to develop carbon sinks [8].

5. Optimization Paths for the Eucalyptus Industry to Serve the Dual Carbon Goals

5.1 Build an Ecological Forest Management Technology System to Achieve Synergy between Carbon Sinks and Ecology

Promote multi-species mixed management models: Expand the application of mixed models such as "Eucalyptus + *Phoebe bournei*" and "Eucalyptus + *Castanopsis hystrix*", with a configuration ratio of 30% Eucalyptus + 70% native tree species. This balances carbon sink efficiency and biodiversity conservation. It is planned to transform 1 million hectares of existing low-efficiency pure forests within 5 years, increasing carbon storage by 15% and biodiversity by 37%.

Optimize full-cycle management: Implement zoned management of "short-cycle raw material forests + long-cycle carbon sink forests". The rotation period of industrial raw material forests is controlled at 7-10 years, while that of carbon sink-dominated stands is extended to more than 15 years. Fully promote bag-controlled slow-release fertilizer and soil-testing formula fertilization technologies to reduce chemical fertilizer usage by over 30% and lower carbon emission intensity.

Establish a sustainable forestland cultivation mechanism: Retain logging residues after harvesting and return them to the field through composting to enhance the soil carbon pool [14]; conduct tree species rotation once every 3 generations, and plant nitrogen-fixing tree species (e.g., *Acacia mangium*) to promote an increase in soil organic carbon content.

5.2 Improve the Market-Oriented Carbon

Sink Mechanism to Activate Ecological Value

Improve carbon sink measurement standards: Based on eddy covariance monitoring and remote sensing technology, establish a three-dimensional carbon measurement model covering the "arbor layer + soil layer + litter layer". Issue the Technical Regulations for Eucalyptus Carbon Sink Accounting to clarify carbon sink measurement methods for mixed forests and coppice forests, ensuring that carbon sink data is verifiable and tradable [11].

Expand carbon sink trading scenarios: Promote the inclusion of Eucalyptus carbon sinks in the national carbon market and establish an offset mechanism of "forestry carbon sinks + industrial emission reduction"; develop carbon sink insurance products to reduce climate risks of carbon sink projects. Replicate Fujian's "forest certificate + land certificate" model, and realize benefit-sharing among "state-owned forest farms + village collectives + farmers" through joint-stock reform to enhance farmers' enthusiasm for participating in carbon sink development [10].

5.3 Strengthen Strategy and Technological Support to Ensure Industrial Transformation

Optimize the strategy guidance system: Include ecological Eucalyptus forest management in the support scope of national reserve forest projects and provide financial subsidies for mixed forest construction; relax logging restrictions on carbon sink-oriented Eucalyptus forests and implement a "long rotation period + flexible logging" management model. Establish an ecological evaluation system for the Eucalyptus industry, and incorporate indicators such as carbon sink capacity and biodiversity into local government assessments.

Increase investment in scientific and technological research and development: Set up a special fund for Eucalyptus carbon sinks to tackle key technologies in breeding high carbon-sequestering varieties, cultivating superior strains with an annual carbon sequestration capacity of over 18 tons per hectare; develop intelligent tending equipment to improve the mechanization rate. Build a national-level Eucalyptus carbon sink monitoring network, with real-time data updates in major producing counties.

6. Conclusions and Prospects

China's Eucalyptus industry has formed a

large-scale development pattern. In 2024, its planting area exceeded 6 million hectares, and the industrial chain covers multiple fields. While ensuring wood security, it also demonstrates strong carbon sink potential and emission reduction value. Its impact on the Dual Carbon Goals has significant duality: scientifically managed Eucalyptus forests can sequester 16 tons of carbon per hectare annually, which can be further increased by 36% through technological optimization; moreover, the biomass substitution effect reduces carbon dioxide emissions by millions of tons each year. However, traditional short-cycle pure forest management leads to severe soil carbon loss and a sharp decline in biodiversity, which restricts the stability of carbon sinks.

In the future, the Eucalyptus industry should be guided by the principles of "ecology first, technology empowerment, and market-driven". It needs to address ecological controversies by promoting ecological forest management technologies such as mixed forest management and optimized full-cycle management; realize the monetization of ecological value by improving carbon sink measurement standards and expanding trading scenarios; and support the low-carbon transformation of the industry by strengthening strategy subsidies and technological research.

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