COMMENTARY

Rewilding artificial forests in China and the world

Hai Ren,[1,2,6,*] Richard T. Corlett,[3,6] Dafeng Hui,[4,6] and Qinfeng Guo[5,6]

[1]Guangdong Provincial Key Laboratory of Applied Botany, South China Botanical Garden of Chinese Academy of Sciences, Guangzhou 510650, China

[2]College of Advanced Agricultural Sciences, University of Chinese Academy of Sciences, Beijing 100049, China

[3]Center for Integrative Conservation and Yunnan Key Laboratory for the Conservation of Tropical Rainforests and Asian Elephants, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Xishuangbanna 666303, China

[4]Department of Biological Sciences, Tennessee State University, Nashville 37209, USA

[5]USDA Forest Service, Eastern Forest Environmental Threat Assessment Center, Research Triangle Park, Durham 27709, USA

[6]These authors contributed equally to this work

*Correspondence: renhai@scbg.ac.cn

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Artificial forests in China and worldwide are mainly composed of homogeneous monocultures. While this design is often suitable for commercial plantations, many of these forests were initially established for environmental purposes. To better support biodiversity and ecosystem health, we advocate for the rewilding of China's non-commercial artificial forests to meet the restoration goals of the Kunming-Montreal Global Biodiversity Framework.

Since the 1980s, countries around the world have developed various types of artificial forests (i.e., planted forests or plantations) for industrial timber production and ecological services, leading to steady growth in artificial forest area and volume. By 2020, global artificial forests covered 293 million hectares, storing approximately 23.85 billion tons of carbon. As of 2022, China's forest area totaled 220 million hectares (23% of the land area), with 80 million hectares being artificial , making China the global leader in artificial forests and contributing roughly a quarter of the world's newly added green area.[1] Since 1995, China has classified its forests into ecological public welfare forests, managed largely for environmental benefits, and commercial forests for production of timber and other forest products. Currently, public welfare forests cover 123 million hectares, with artificial forests accounting for 21.3% and storing approximately 1.1 billion tons of carbon.[2] Artificial forests are widely planted for ecological restoration in China, accounting for 47.5% of the total ecological restoration land.[3]

Although artificial forests have played a critical role in maintaining ecological security in China, with enormous ecological, economic, and social benefits, they are now increasingly out of step with China's growing environmental ambitions.[3] These include commitments to greatly increase forest carbon sinks under the 2015 Paris Agreement and to have 30% of degraded ecosystems under effective restoration by 2030 under the recent Kunming-Montreal Global Biodiversity Framework.

PROBLEMS OF ARTIFICIAL FORESTS IN CHINA AND AROUND THE WORLD

Artificial forests differ from natural forests in multiple ways that reduce their environmental value. First, they have low species and structural diversity (Figure 1). Approximately 90% of artificial forests in China are even-aged monocultures, with coniferous forests accounting for two-thirds of these. These forests typically exhibit a simple spatial structure, lacking intermediate shrub layers and surface vegetation.[1] The simple structure leads to limited functional diversity, poor stress resistance, and increased susceptibility to pests and diseases. In addition, multiple generations of continuous cropping in many of these artificial forests have resulted in a decline in soil fertility.

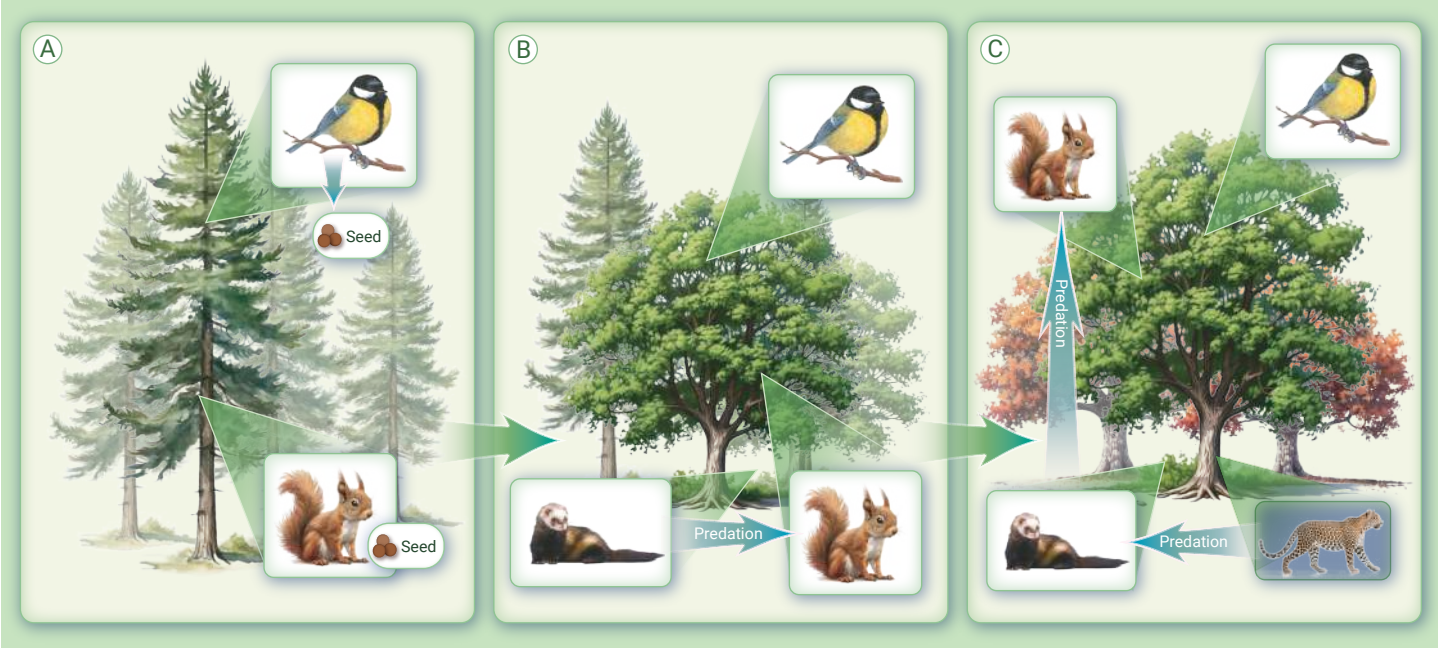

Figure 1. The number of plant and animal species gradually increases during rewilding artificial forests.

Second, many planted forests around the world use largely exotic species and neglect native species. For example, artificial forests in China frequently rely on non-native species, such as eucalyptus and slash pine. These exotic species are often introduced into ecosystems that have been reconstructed following the destruction of native vegetation, resulting in low species diversity and damaging the landscape integrity. This practice also has adverse effects on the original ecosystems. In addition, the use of rare and endangered local plants in artificial forests is none or minimal.[1]

Third, the planted forests lack the heterogeneity and structural diversity required for ecosystem health and sustainability. Artificial forests in China are often managed to appear homogeneous for economic purposes, ignoring the heterogeneity in species composition, spatial structure, age structure, and

resource utilization that occur in natural forests. For example, high-density artificial forests, typically consisting of same-aged conifers, often lead to soil acidification, which hinders the growth of understory shrubs and grasses. Consequently, these forests fail to provide the environmental conditions needed for the survival of a diverse flora and fauna.

Fourth, some inappropriate practices in China's artificial forests lead to low overall quality. The average unit volume of China's artificial forests is only 59.3 m^3/ha, which is 20% of that in Germany.[2] Practices such as large-scale logging operations, excessive tree removal, and inadequate nurturing management ignore natural succession processes, natural renewal, and forest health, resulting in low forest productivity.

The space for the continued expansion of artificial afforestation in China is becoming increasingly limited due to constraints on available land resources, site conditions, and climate change pressures. It is estimated that China still has about 40 million hectares of land available for afforestation, but half of it is in arid and semi-arid areas with rainfall below 400 mm, making afforestation much more difficult.[1] Additionally, the ecological connections between artificial forest areas and agricultural, residential, and urban green areas have been overlooked.

THE DEMAND FOR ECOSYSTEM RESTORATION IN CHINA

China aims to double its gross domestic product (GDP) from 2020 by 2035. To achieve this goal while ensuring the coordinated development of society, economy, and ecology, China must also significantly enhance its ecosystem service. To comply with international conventions, such as Convention on Biological Diversity (CBD), the Sustainable Development Goals (SDGs) 2030, the UN Framework Convention on Climate Change, and the UN Decade on Ecosystem Restoration, China must support biodiversity conservation, climate change mitigation, and sustainable development. This will help achieve modernization of harmonious coexistence between humans and nature. Essential to this effort is the concept of "one health" and the systematic governance of terrestrial ecosystems, including forests, grasslands, and wetlands. Artificial forests should be utilized to their fullest potential as carbon sinks, water reservoirs, financial assets, food sources, and habitats for diverse species. These forests already occupy huge areas in China and may continue to increase, but plant and animal diversity and ecosystem services have not been addressed.

Given the limited opportunities to improve the quality of natural forests compared to artificial ones, rewilding artificial forests to more closely resemble natural ecosystems should be considered. Rewilding refers to the increase in wildness in specific landscapes, with particular emphasis on restoring wildness and spontaneity, and ultimately improving ecosystem complexity and biodiversity.[4] This approach can help create ecological public welfare forests that are nature centric. In doing so, the focus should expand from only plant species to include the systematic management of plants, animals, microorganisms, and environmental factors.

Transforming artificial forests into ecological public welfare forests involves enhancing biodiversity protection, restoration, and sustainable use through the coordinated development of structure, function, dynamics, and services of artificial forests. Ultimately, this will improve ecosystem function and services and enhance the diversity, stability, and sustainability of ecosystems.

RECOMMENDATIONS

Over the last decade, China has shifted its environmental strategy to prioritize quality and long-term sustainability over mere quantity and immediate results. Policies such as the ecological civilization framework, ecological redlines, the national park system, and national botanical garden system reflect this focus. Rewilding artificial forests aligns with these initiatives, enhancing ecological, economic, and social functions by restoring biodiversity and ecosystem services.

Transforming artificial forests into ecological public welfare forests requires addressing current challenges, with an initial focus on restoring plant and animal diversity. Rewilding aims for self-sustaining ecosystems, though early human intervention may be needed to overcome land-use legacies and set recovery on the correct trajectory. In small artificial forests adjacent to natural ones, natural seed dispersal may suffice; large areas with fewer dispersal fauna will need active support.

A key first step is diversifying forest canopy species and structure. In open canopies, underplanting with diverse native tree species may be enough. However, dense canopies may require selective tree remove for light penetration, facilitating the establishment of understory species. Using local sources for seeds and other planting materials is ideal, with rare and threatened species included when possible.

As diverse builds, more animals and plant species will naturally colonize (Figure 1). However, some species, especially those historically present, may need active reintroduction. For instance, habitat rewilding in the Northeast Tiger and Leopard National Park has helped restore tiger and leopard populations, and the trophic structure and function of the ecosystem. Large animals have ecological roles that cannot be substituted by smaller species.[4] But the reintroduction of apex carnivores and large herbivores could lead to human-wildlife conflicts, particularly in areas with dense human populations. Effective planning, monitoring, and mitigation (e.g., barriers, deterrents, and compensation) will be essential.

On a regional scale, integrating forests with surrounding landscapes – mountains, waters, forests, fields, lakes, grasslands, and sands – should prioritize forest restoration. This involves creating wildlife corridors, native plant patches, habitats of rare and endangered species, and diverse ecosystems that enhance ecological connectivity.[5] Such an approach will provide the necessary space for the restoration of animal communities and enhance the resilience of artificial forests to climate change.

Scientific and technological innovation will also be crucial. This includes developing native plants and high-value plants, protecting rare and endangered animals through conservation, advancing multi-trophic restoration, training ecologists, and ensuring strategic spatial planning, particularly for corridors.

Ultimately, restoring diverse communities and apex animal species supports China's goal of high-quality restoration on 30% of degraded ecosystems, as set by the Kunming-Montreal Global Biodiversity Framework. Given the vast scale of the problem and the presence of artificial forests in all the climate types in China and around the world, this ambitious effort will promote harmonious human-nature coexistence and support global well-being. International collaboration and information (data and knowledge) exchange will further enhance these outcomes.

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AUTHOR CONTRIBUTIONS

All authors conceived the original idea. Hai Ren wrote the draft. Richard T. Corlett, Dafeng Hui and Qinfeng Guo provided critical revisions.

DECLARATION OF INTERESTS

The authors declare no competing interests.