

Forest restoration must navigate trade-offs between environmental and wood production goals

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Forest restoration schemes should prioritize restoring native forests for greatest climate and environmental benefits, but these benefits incur a

trade-off with wood production in comparison with tree plantations.

Diverse native forests store more above-ground carbon, provide more water to nearby streams, and better support biodiversity and prevent soil erosion than simple tree plantations, a major new study published today in the journal *Science* has found—but plantations have an advantage in wood production.

The study looked at the relative benefits of restoring native forests versus establishing a range of simple tree plantations in terms of biodiversity conservation and four key functions of value to humans—or '[ecosystem services](#)'—provided by a forest: carbon storage, soil erosion control, water provisioning, and wood production.

Forest [restoration](#) is gathering pace worldwide, in part as a way to tackle climate change: deforestation is a major source of carbon emissions, and forest restoration can be a 'nature-based climate solution' to counter global warming. In many cases, forest restoration is also conducted for the water provisioning and flood regulation functions of forests, and as a means to prevent soil erosion and produce wood products.

"Establishing a tree [plantation](#) is useful for producing wood—but not so good for restoring biodiversity. This is a huge missed opportunity for conservation," said Dr. Fangyuan Hua, a researcher previously based in the University of Cambridge's Department of Zoology, and first author of the paper. Hua now works at Peking University's Institute of Ecology in China.

She added: "When the goal of a forest restoration scheme includes wood production, then there's a trade-off to be made between environmental and production outcomes."

Forest restoration schemes aimed at providing ecosystem services tend

to involve tree plantations of just one or a small number of tree species, rather than the restoration of diverse native forests, based on an implicit assumption that tree plantations are just as effective in delivering these services. But the authors say there is no robust scientific evidence for this.

The current synthesis involved an international, cross-disciplinary team of researchers from seven countries, and it is based on an unprecedentedly large database consisting of almost 26,000 records from 264 studies conducted in 53 countries.

"This is the first time that the relative performance of different forest restoration approaches in delivering forests' most salient services has been assessed simultaneously. We can now begin to understand the synergies and trade-offs across different restoration goals, and so help inform decision-making," said Professor Andrew Balmford in the University of Cambridge's Department of Zoology, senior author of the paper.

The study found that as with biodiversity, all three environment-oriented ecosystem services—aboveground carbon storage, [soil erosion](#) control, and water provisioning—are delivered better by native forests than by tree plantations. Soil erosion control in particular has the most to lose from plantation-style forest restoration, and the shortfall of plantations in water provisioning is more serious in drier climates—precisely where water is scarcer.

"When restoration goals are about environmental benefits, even if not specifically for the sake of biodiversity conservation, we should aim to restore native forests—and biodiversity will gain as a co-benefit," said Hua.

However, for wood production, the limited evidence available showed

that tree plantations can outperform native forests, highlighting a critical trade-off.

Tree plantations worldwide typically use fast-growing species like pines, firs, and *Eucalyptus*. These trees tend to grow tall and straight, and in actively managed plantations their growth is often enhanced by fertilizers and weeding to prevent other plants competing for nutrition and light.

In contrast, native forests contain a mix of different tree, shrub, and herbaceous species, and they tend not to be managed for growth. This provides a more suitable habitat with diverse food and other resources for a range of plants and animals to thrive, but also means that wood production may be less efficient.

"The trade-off between the environmental and production benefits a [forest](#) can provide has not been discussed much before. Restoration probably cannot meet all goals at once," said Professor David Edwards at the University of Sheffield's School of Biosciences and another senior author of the study.

In addition to a need to weigh competing goals, this finding also means that plantations might indirectly provide environmental benefits, by allowing other, higher-biodiversity forests to be 'spared' from being cut down for wood production.

"Plantations need to be integrated into a coherent land-use plan, so that their better performance at producing wood gets translated into improved conservation of environmentally valuable forests elsewhere," Balmford added.

The study also found that for many old or abandoned plantations across the world that seem no longer used for [wood](#) production, their

environmental performance falls short of native forests. Given that these plantations seem to be common, there are probably significant environmental benefits to be gained from restoring them to [native forests](#).

The United Nations (UN) have declared 2021-2030 the 'UN Decade on Ecosystem Restoration'. Along with many other climate-related initiatives, this promotes the scaling-up of restoration efforts on a global scale to breathe new life into our degraded ecosystems, including the restoration of forests on millions of hectares of deforested and degraded land across the world. Such restoration efforts have the potential to generate immense environmental and social benefits—but only if they are guided by a robust understanding of their consequences for environmental and other outcomes.

More information: Fangyuan Hua et al, The ecosystem service and biodiversity contributions and trade-offs of contrasting forest restoration approaches, *Science* (2022). [DOI: 10.1126/science.abl4649](https://doi.org/10.1126/science.abl4649).
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