

# Forests with multiple tree species are 70% more effective as carbon sinks than monoculture forests, study finds

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To slow the effects of climate change, conserve biodiversity, and meet the sustainable development goals, replanting trees is vital. Restored forests store carbon within the forest's soil, shrubs, and trees. Mixed forests are especially effective at carbon storage, as different species with complementary traits can increase overall carbon storage.

Compared to single-species forests, mixed forests are also more resilient to pests, diseases, and climatic disturbances, which increases their long-term [carbon storage](#) potential. The delivery of other ecosystem services is also greater in mixed species forests, and they support higher levels of biodiversity.

Although the benefits of diverse forest systems are well known, many countries' restoration commitments are focused on establishing monoculture plantations. Given this practice, an international team of scientists has compared [carbon stocks](#) in mixed planted forests to [carbon stocks](#) in commercial and best-performing monocultures, as well as the average of monocultures.

Their work is published in *Frontiers in Forests and Global Change*.

"Diverse planted forests store more carbon than monocultures—upwards of 70%," said Dr. Emily Warner, a postdoctoral researcher in ecology and biodiversity science at the Department of Biology, University of Oxford, and first author of the study. "We also found the greatest increase in carbon storage relative to monocultures in four-species mixtures."

## **Species richness increases carbon storage potential**

The researchers analyzed studies published since 1975 that directly compared carbon storage in mixed and single-species forests, and combined this with previously unpublished data from a global network

of tree diversity experiments. "We wanted to pull together and assess the existing evidence to determine whether forest diversification provides carbon storage benefits," Warner explained.

The mixed planted forests assessed in the study ranged in [species richness](#) from two to six species. In the data set the scientists worked with, four-species mixtures were the most effective carbon sinks. One such mix was made up from different broadleaf trees, which can be found across Europe. Mixes with two species also had greater above-ground carbon stocks than monocultures and stored up to 35% more carbon. Forests made up of six species, however, showed no clear advantage to monocultures.

Accordingly, the researchers were able to show that diversification of forests enhances carbon storage. Altogether, above-ground carbon stocks in mixed forests were 70% higher than in the average monoculture. The researchers also found that mixed forests had 77% higher carbon stocks than commercial monocultures, made up of species bred to be particularly high yielding.

## **Forests for the future**

"As momentum for [tree planting](#) grows, our study highlights that mixed species plantations would increase carbon storage alongside other benefits of diversifying planted forests," said Dr. Susan Cook-Patton, a senior forest restoration scientist at The Nature Conservancy and collaborator on the study. The results are particularly relevant to forest managers, showing that there is a productivity incentive for diversifying new planted forests, the researchers pointed out.

While showing the increased potential of mixed forests to store more carbon, the researchers cautioned that their study is not without limitations, including the overall limited availability of studies

addressing mixed vs. monoculture forests, particularly studies from older forests and with higher levels of tree diversity.

"This study demonstrates the potential of diversification of planted forests, and also the need for long-term [experimental data](#) to explore the mechanisms behind our results," Warner said. "There is an urgent need to explore further how the carbon [storage](#) benefits of diversification change depending on factors such as location, [species](#) used and [forest](#) age."

**More information:** Young mixed planted forests store more carbon than monocultures—a meta-analysis, *Frontiers in Forests and Global Change* (2023). [DOI: 10.3389/ffgc.2023.1226514](https://doi.org/10.3389/ffgc.2023.1226514)

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