Mature forests are vital in frontline fight against climate change, research reveals

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Mature forests have a key role to play in the fight against climate change—extracting carbon dioxide (CO_2) from the atmosphere and locking it into new wood, a new study reveals.

Researchers discovered that older trees responded to increased

atmospheric levels of CO_2 by increasing production of woody biomass—countering existing theories that mature woodland has no capacity to respond to elevated CO_2 levels.

The experts found exposure to elevated levels of the greenhouse gas (ambient atmosphere + 150 parts per million CO_2; about a 40% increase) increased wood production by an average of 9.8% over a seven-year period. No corresponding increase in production of material such as leaves or fine roots, which release CO_2 into the atmosphere relatively quickly, could be detected.

Their findings published in *Nature Climate Change*, support the role of mature forests as medium-term (decades long) carbon stores and natural climate solutions—thanks to data from the long-running free-air CO_2 enrichment (FACE) experiment at the University of Birmingham's Institute of Forest Research (BIFoR), in central England.

Researchers at BIFoR established a FACE experiment in a 180-year-old deciduous woodland dominated by 26-m tall English (or 'pedunculate') oak trees—six 30 meter diameter plots, three exposed to elevated CO_2 with the other three plots acting as a control.

Lead author Professor Richard Norby, from the University of Birmingham, said, "Our findings refute the notion that older, mature forests cannot respond to rising levels of atmospheric CO_2, but how they respond will likely depend on the supply of nutrients from the soil.

"Evidence from BIFoR FACE of a significant increase in woody biomass production supports the role of mature, long-established, forests as natural climate solutions in the coming decades while society strives to reduce its dependency on carbon."

FACE experiments mimic future atmospheric composition and provided

valuable data on interaction between forests, atmosphere, and climate. Previous experiments found that forest productivity can increase under elevated CO_2 but were conducted in young tree plantations—raising questions about whether older trees would respond in the same way.

Co-author and BIFoR Director Professor Rob MacKenzie, from the University of Birmingham, said, "We believe these results, at about the halfway point of our fifteen-year experiment at BIFoR FACE, will prove invaluable for policy makers around the globe as they grapple with the complexities of climate change.

"FACE experiments such as ours provide foundations for predictions of future atmospheric CO_2 concentrations and so greatly improve confidence in policy decisions. But even if the increase in tree growth translates to a medium-term increase in carbon storage in forests, this in no way offers a reason to delay reductions in fossil fuel consumption."

The BIFoR FACE experiment began changing the atmosphere around the forest in 2017 and measured the effect of elevated CO_2 on wood production by using laser scanning to convert measured tree diameters into wood mass.

Scientists calculated the overall growth of the forest (called net primary productivity, NPP) by combining wood production of the oaks and understory trees with the production of leaves, fine roots, flowers, and seeds, and even the amount of biologically active compounds released from roots.

Researchers found that NPP was 9.7% and 11.5% larger in elevated CO_2 than in ambient conditions in 2021 and 2022, respectively—an increase of some 1.7 metric tons of dry matter per hectare per year. Most of this increase was due to wood production and there was no change in fine-root or leaf mass production.

To put this extra forest carbon storage in context, it is equivalent, over a hectare and over a year, to 1% of the CO_2 emitted by a single commercial passenger aircraft flying one-way from London to New York. The whole amount of carbon taken up by the long-established forest per hectare per year is 10-times larger. These values give some indication of the scale of forest protection and management required to offset even essential fossil-fuel emissions.

The BIFoR FACE experiment will continue into the 2030s to analyze long-term responses and the interactions between forest carbon, other plant nutrients, and the forest food web.

More information: Enhanced woody biomass production in a mature temperate forest under elevated CO2, *Nature Climate Change* (2024). DOI: 10.1038/s41558-024-02090-3

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