

Global environmental changes leading to shorter, younger trees

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Forests are becoming shorter and younger because of a range of factors, a new study says. Credit: Ed van duijn, Unsplash

Ongoing environmental changes are transforming forests worldwide, resulting in shorter and younger trees with broad impacts on global ecosystems, scientists say.

In a global study published in the May 29 issue of the journal *Science*, researchers led by the U.S. Department of Energy's Pacific Northwest National Laboratory found that rising temperatures and [carbon dioxide](#) have been altering the world's forests through increased stress and [carbon dioxide](#) fertilization and through increasing the frequency and severity of disturbances such as wildfire, drought, wind damage and other natural enemies. Combined with forest harvest, the Earth has witnessed a dramatic decrease in the age and stature of forests.

"This trend is likely to continue with climate warming," said Nate McDowell, a PNNL Earth scientist and the study's lead author. "A future

planet with fewer large, old forests will be very different than what we have grown accustomed to. Older forests often host much higher biodiversity than young forests and they store more carbon than young forests."

Carbon storage and rich biodiversity are both keys to mitigate [climate change](#).

The study, "Pervasive shifts in forest dynamics in a changing world," determined that forests have already been altered by humans and will mostly likely continue to be altered in the foreseeable future, resulting in a continued reduction of old-growth forests globally.

Three conditions generate a deforestation loop

The researchers used satellite imagery along with a detailed literature review to conclude that the globally averaged tree size has declined over the last century and is likely to continue declining due to continuing environmental changes.

Several factors have led to the loss of [trees](#) through human activity and natural causes—clear-cutting, wildfire, insects and disease are leading causes. Known as deforestation, the phenomenon has led to an imbalance of three important characteristics of a diverse and thriving forest: (1) recruitment, which is the addition of new seedlings to a community; (2) growth, the net increase in biomass or carbon; and (3) mortality, the death of forest trees.

"Mortality is rising in most areas, while recruitment and growth are variable over time, leading to a net decline in the stature of forests," said McDowell. "Unfortunately, mortality drivers like rising temperature and disturbances such as wildfire and insect outbreaks are on the rise and are expected to continue increasing in frequency and severity over the next century. So, reductions in average forest age and height are already happening and

they're likely to continue to happen."

Vegetation dynamics are changing

The conditions promoting deforestation will likely accelerate, drastically altering the living conditions for plants and animals, McDowell said.

"Over the last hundred years we've lost a lot of old forests," McDowell said. "And they've been replaced in part by non-forests and in part by young forests. This has consequences on biodiversity, climate mitigation, and forestry."

Wide-ranging impact

The study also reveals that other mechanisms of deforestation—"chronically changing drivers"—are underway. They include:

- **Atmospheric carbon dioxide:** Carbon dioxide levels in the atmosphere have increased dramatically since the Industrial Revolution and are projected to continue rising over the next century. Higher levels of carbon dioxide can increase a tree's growth rate and seed production. However, such carbon dioxide fertilization appears to only happen in younger forests with abundant nutrients and water. Most forests globally are exposed to limitations in nutrients and water, which drastically reduces the carbon dioxide benefits to trees.
- **Temperature:** Rising temperatures limit life-giving photosynthesis, leading to lower growth, higher mortality, and reduced regeneration. This is one key to shorter trees, the study determined.
- **Droughts:** They're expected to increase in frequency, duration and severity globally. Drought can directly cause tree death or indirectly lead to mortality through associated increases in insect or pathogen attack.

Other factors are altering the face of the world's forests:

- Wildfire is increasing in many forests worldwide and future fires may be more

frequent than they have been in the past 10,000 years in some regions, the study found. Plant growth following forest fires may be slow or absent due to elevated temperatures.

- **Biotic deforestation disturbances**—by insects, fungi and choking vines—have been on the increase. The carbon storage lost to insects each year is the same as the amount of carbon emitted by 5 million vehicles, a study published last year says. This is expected to continue with warming, along with other biotic deforestation disturbances, such as fungi and bacteria. In the tropics, vines that use other plants as host structures are choking trees to death.
- **Wood harvests** alone has had a huge impact on the shift of global forests towards younger ages or towards non-forest land, reducing the amount of forests, and old-growth forests, globally. Where forests are re-established on harvested land, the trees are smaller and biomass is reduced.

McDowell collaborated with more than 20 scientists to produce the deforestation study, which included data and observations made in more than 160 previous studies.

"Environmental changes are making disturbances worse, and this is causing a change in vegetation dynamics towards shorter, younger forests," McDowell said.

More information: "Pervasive shifts in forest dynamics in a changing world" *Science*, science.sciencemag.org/cgi/doi/10.1126/science.aaz9463

Provided by Pacific Northwest National Laboratory

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