# Forest edges in the tropics increase carbon emissions

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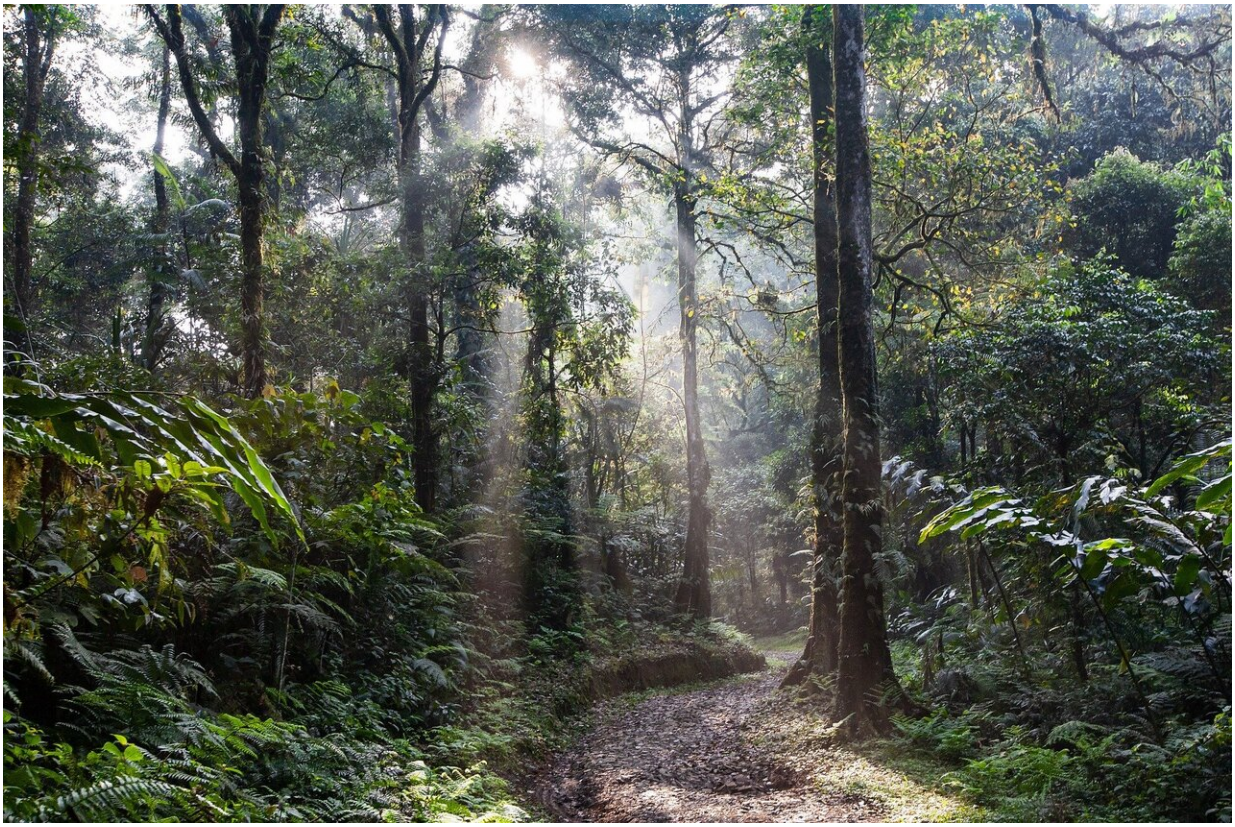

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The deforestation of the tropical rainforests is progressing unstoppably. According to scientists at the Helmholtz Centre for Environmental Research (UFZ), these forests are becoming fragmented at a higher rate

than expected. By analyzing high-resolution satellite data, they were able to measure even the smallest piece of tropical forest and, for the first time, study the changes in tropical fragmentation. In a paper for *Science Advances*, they discuss how this previously unnoticed and underestimated increase in fragmentation to almost one third of the forest area has consequences for the global carbon cycle. Because of increased tree mortality, large amounts of carbon are released at the forest edges. Model simulations also show that these emissions could increase in the future. Only through less deforestation can the process be slowed down.

The UFZ modeling team used satellite data from 2000 and 2010 with a very high resolution of 30 meters. They were able to compare where in Central and South America, Africa, and South-east Asia connected tropical forests still exist or where they have disappeared. With the help of a complex cluster algorithm and high-performance computers, they found that the number of isolated forest areas increased by more than 20 million to 152 million between 2000 and 2010.

This increase in forest fragments is particularly serious because it has also increased the proportion of forest edges in the total forest area. The forest edge is defined as the area of forest that extends 100 meters into the forest from open land. This edge area increased from 27 to 31% (i.e. from 517 to 589 million hectares) between 2000 and 2010. "This situation has deteriorated so much that now almost one third of the world's tropical forest areas are in edge areas. If deforestation is not stopped, this trend will continue," says lead author and UFZ modeler Dr. Rico Fischer. The effect of accelerated fragmentation occurred mainly in the tropics of Africa. There, the number of forest fragments increased from 45 million to 64 million within only 10 years. The proportion of the forest edge in the total forest increased from 30 to 37% (2000: 172 million hectares; 2010: 212 million hectares). In contrast, the proportion of forest edges in Central and South America rose by only 2% to 25%

(2000: 215 million hectares; 2010: 232 million hectares).

So far, the carbon balance of tropical forest edges has hardly been studied in detail. However, this forest area is important because fragmentation changes various ecological processes in the edge areas. "The edge, unlike the forest interior, is subject to direct sunlight. It is more exposed to the wind. Humidity also decreases in the edge areas. The altered micro-climate particularly damages the large trees that depend on a good water supply," explains Fischer. As a result, more trees die at the forest edge because they are more stressed there than in the protected interior of a forest. This also has an impact on carbon balances. Micro-organisms emit carbon dioxide when decomposing the dead trees. Because fewer trees survive that need to take up carbon for the growth of the crown, trunk, and roots, less carbon dioxide is sequestered from the atmosphere. "This means that large amounts of carbon are released into the atmosphere at the edges of tropical forests," says Fischer.

For the first time, the UFZ scientists have now been able to precisely model how high these carbon emissions are and how they could develop in the coming decades. From the high-resolution remote sensing data, they calculated how much biomass is present in each edge area of a forest fragment in the tropics. From this, they determined the carbon emissions caused by increased tree mortality for all forest edges. The result: while around 420 million tons of carbon were emitted in 2000, this had already risen to 450 million by 2010. "In the tropics, deforestation alone releases around 1,000 to 1,500 million tons of carbon every year. If we consider the additional effect of the forest edges, this is a worrying finding because the tropical rainforest should actually be a carbon sink—and not a carbon source," says co-author and UFZ biophysicist Prof. Dr. Andreas Huth. The fragmentation of tropical forests affects not only the global carbon balance but also biodiversity. The UFZ modelers showed that the distances between the forest

fragments are becoming increasingly larger. "This makes the long-term survival of animal species such as the jaguar, which depends on large, connected forest areas, more difficult," says co-author Dr. Franziska Taubert.

A look into the future also does not bode well, as the UFZ team found out using modeling. "To do this, we used a fragmentation model from physics and simulated the future of each individual tropical forest fragment," explains Taubert. Assuming that the current rate of tropical deforestation is not reduced, the proportion of forest edges in the total forest will increase from 31% in 2010 to almost 50% in 2100. Even if deforestation rates in the tropics decrease by half, the proportion of edge areas will still increase to 40%. The process can be slowed only if deforestation in the tropics is stopped by 2050. In this case, the proportion of forest edges in 2100 will remain at the current level of about 30%. The further increase in forest fragmentation would also have consequences for carbon emissions. "If the current dynamics of fragmentation continue at a constant rate, forest edges will release 530 million tons of carbon annually by 2100. Only if deforestation of the rainforest is stopped from 2050 onwards can emissions be limited to a maximum of 480 million tons of carbon," says Fischer.

The study is published in *Science Advances*.

**More information:** Accelerated forest fragmentation leads to critical increase in tropical forest edge area, *Science Advances*, DOI: 10.1126/sciadv.abg7012

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