New forest condition monitor shows dynamic changes in forests resulting from extreme climate change events

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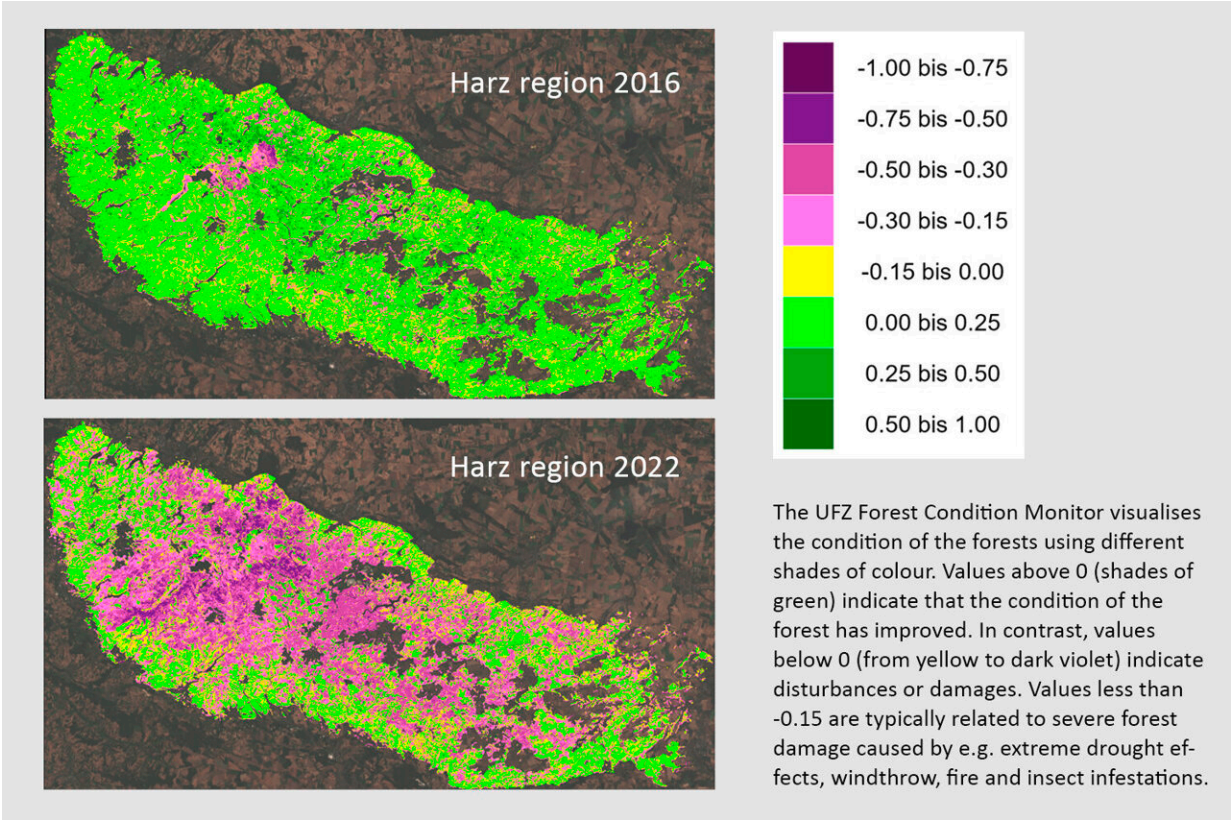

According to the UFZ forest condition monitor, 52 percent of the forest on the whole and particularly 76 percent of the conifers in the Harz region were severely damaged by 2022. In contrast, in 2017 only 9 percent of the forest and 8 percent of conifers showed severe damages. Credit: UFZ forest condition monitor / Data source: ESA (Copernicus Sentinel-2)

According to the German Federal Ministry of Food and Agriculture (BMEL), large parts of the German forest show an increase in damage as a result of the extreme drought period in Germany during recent years. However, hardly any data is available capturing the dynamic spatio-temporal changes in forested landscape at large scales.

In a study published in *Remote Sensing of Environment*, a research team coordinated by the Helmholtz Centre for Environmental Research (UFZ) describes how satellite data can be used to derive the condition of forested landscapes in Germany.

This information serves as the basis for the new UFZ forest condition monitor, which provides detailed information on forest characteristics in maps with a spatial resolution of 20 meters. These indicate a significant increase in damaged forest areas over the period from 2016 to 2022, especially in regions of central Germany such as Harz, Sauerland and Saxon Switzerland.

Roughly one-third of the area of Germany, approximately 11 million hectares, is covered by forest. The distribution of these forests and the dominant tree species are largely known.

"However, what we are missing to date is specific information on large-scale and area-wide forest conditions, which still include regional aspects and [their] change dynamics," says UFZ remote sensing specialist Dr. Daniel Doktor.

The UFZ forest condition monitor is now intended to close this gap: "We have developed an index representing the dynamic condition changes in Germany's forest areas. This index is displayed as seasonal and annual maps within our monitor," he says.

In contrast with, for example, the forest condition report of the German

Federal Ministry of Food and Agriculture (BMEL), which is designed to statistically sample the average forest condition in Germany, the monitor thus provides information with a greater spatial and temporal resolution. Although the BMEL report is based on highly precise forest inventories, it is only specified for roughly 400 such forest plots with a resolution of 16 kilometers throughout Germany.

The UFZ researchers derived the forest condition using Sentinel-2 data from the European Space agency (ESA).

"Sunlight is reflected differently by each tree species over the course of the year. This can be captured very well by the satellites, which store the information as numerical values. They depict vegetation characteristics, e.g. pigment and water content or canopy structure," says Dr. Maximillian Lange, first author of the study. "The more these values deviate from the average reflectivity, the more likely it is that the vegetation is stressed or destroyed."

The researchers extracted representative reflectance time series for healthy populations of the four dominant tree species: oak (Sessile and Pedunculate oak), European beech, Norway spruce and Scots pine, over the years 2016 to 2022. These were subsequently used as a reference to detect anomalies in forest conditions. The researchers were thus able to determine a so-called forest condition anomaly index. It quantifies the extent to which the respective reflectances deviate from the reference—in other words, the extent to which the actual forest condition differs from the expected condition.

This index is available for all forested areas across Germany with a spatial resolution of 20 meters. However, the team still faces challenges calibrating the forest condition anomaly index, quantifying uncertainties and minimizing these.

The online version of the UFZ forest condition monitor shows not only the forest condition, but also the spatial distribution of the four dominant tree species and their respective phenology, such as bud burst and leaf coloration. It also provides multiple vegetation index maps that highlight specific vegetation properties. In addition, modeled tree species distribution maps are part of the platform. They are based on three different climate scenarios (RCP 2.6, RCP 4.5 and RCP 8.5) defined by the Intergovernmental Panel on Climate Change.

However, the main focus of the UFZ forest condition monitor lies on the forest condition anomaly maps, quantified as values between -1 and 1. For example, values above 0 (represented within the map viewer in various green shades) indicate an increasing chlorophyll and water content or increased foliage. Hence, they represent an improved forest condition. In contrast, values below 0 (colors from yellow to dark violet) indicate disturbances or damage. Values less than -0.15 are typically related to severe forest damage, caused by extreme drought effects, windthrough, fire and insect infestations.

The maps show a substantial increase in damaged forest area in central Germany, such as in the Harz region, the Thuringian forest, Sauerland or Saxon Switzerland, especially after 2018. According to the UFZ forest condition monitor, 52% of the forest on the whole, and particularly 76% of the conifers in the Harz region, was severely damaged by 2022. In contrast, in 2017 only 9% of the forest and 8% of conifers showed severe damage.

"Heat, drought and insects as well as their interaction negatively affect the forest and result in subsequent damage such as windfall and elevated risk of fire," explains UFZ researcher Anne Reichmuth, describing the underlying drivers. In particular, forests of the central German upland regions in which spruce was planted after 1945 were affected.

However, there are also significant regional losses among pine, beech and oak trees. The increasing occurrence of mass reproductions of harmful insects is a significant factor in the poor conifer condition. Deciduous trees are especially affected by so-called complex diseases that weaken the trees' immune system and hence their defensive strength.

The UFZ forest condition monitor also shows how regions can be affected to varying degrees by extreme climate events. For example, the forest condition in the mountain ranges of the Black Forest and the Erzgebirge (Ore mountains) has not deteriorated substantially between 2016 and 2022. The silver fir, which is common in the Black Forest, is better adapted to climate change than the Norway spruce.

Also, central and northeast Germany were more affected by the drought. However, the Erzgebirge region was less impaired in higher elevations.

"The UFZ forest condition monitor especially seeks knowledge transfer to the authorities, such as the federal state forests and the national park authorities," says Doktor. The maps can be used to clearly show the dynamic forest ecosystem changes caused by extreme climate events.

More information: Maximilian Lange et al, A continuous tree species-specific reflectance anomaly index reveals declining forest condition between 2016 and 2022 in Germany, *Remote Sensing of Environment* (2024). DOI: 10.1016/j.rse.2024.114323

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https://phys.org/news/2024-08-forest-condition-dynamic-forests-resulting.html