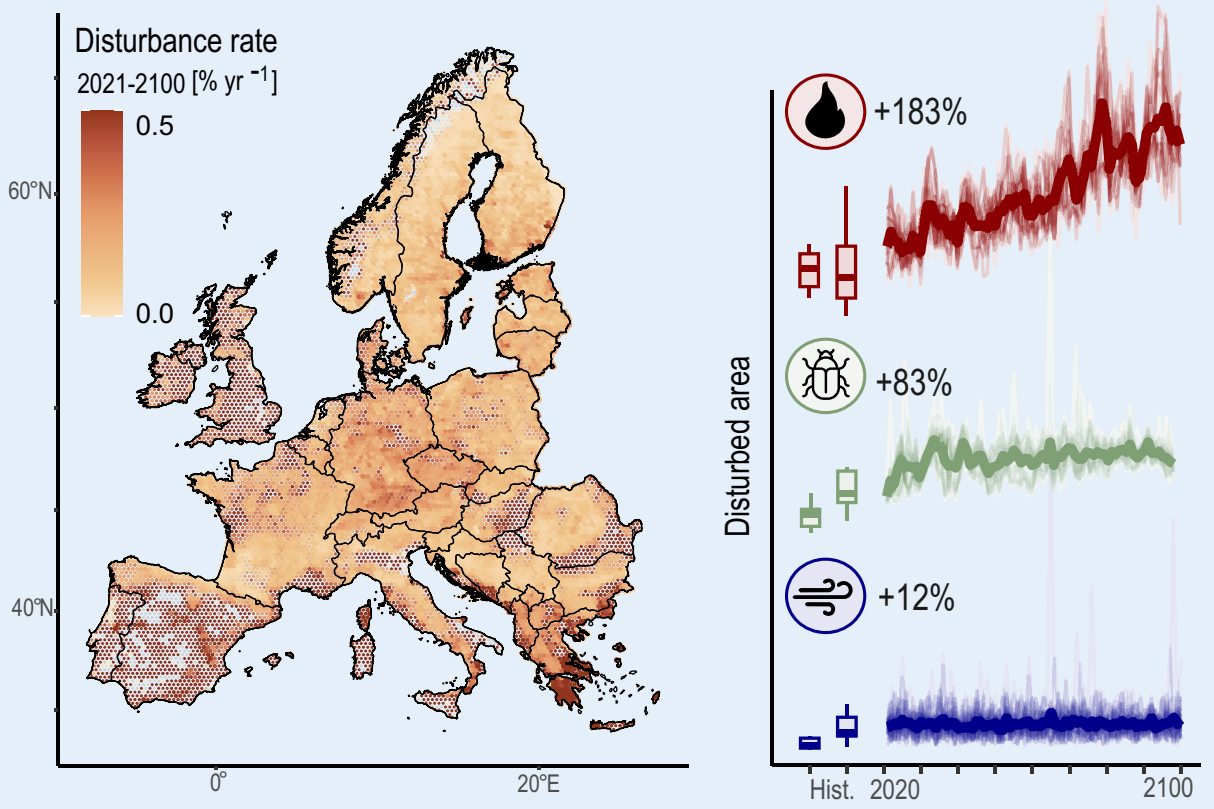
The future of European forest disturbance regimes

Forests not only provide renewable materials and services to society but also harbour biodiversity and store carbon. Over the past decades, disturbances from wildfires, insect outbreaks, and storms have increased considerably across Europe, threatening ecosystem services.

Different disturbance agents can interact with each other, and the feedbacks between disturbance, vegetation and climate can have dampening or amplifying effects on future disturbances. Due to this complexity, robust and long-term projections of disturbance regimes at large spatial scale and high resolution have been missing so far. They are needed, however, to quantify future risks to forest ecosystem services and to develop risk mitigation strategies and integrated policy instruments.



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A new modelling framework simulates future trajectories of forest disturbance at high spatial resolution (100 × 100 m) across all of Europe (187 million hectares of forests) until 2100 under different climate change scenarios. The framework is based on deep learning and trained with a large body of local projections made by process-based forest models and integrates remotely sensed disturbance data for continental Europe.

Results show the average disturbance rate in Europe (i.e., the percent of the forest area disturbed annually) across disturbance agents until the end of the 21st century (left) and the development of area disturbed by wildfire, bark beetles, and wind over time (right). In the right panels, fine lines show the individual simulated trajectories (note the individual extreme disturbance years), and bold lines indicate the mean trend across all individual simulations. For reference, boxplots show historical observations of area disturbed for the periods 1986–2000 and 2001–2020, and percentage values refer to a change between the period 1986–2020 and 2081–2100.

What is the scientific evidence?

The increase of forest disturbances in Europe is projected to continue, reaching unprecedented levels in the second half of the 21st century. Regardless of climate scenario, disturbance rates for 2081–2100 were projected to be substantially higher than in recent decades (1986–2020), which already had the highest level of disturbance in at least 170 years. Future trajectories depend on the climate scenario, with disturbances projected to increase by up to +122% under the severe climate change scenario RCP8.5 (+61% under the moderate scenario RCP4.5 and +31% under the mild scenario RCP2.6). This means that if climate change continues unabated, the area disturbed is expected to more than double relative to values of the recent past. Wildfires respond most strongly to climate change. They are projected to be the disturbance agent most strongly driving future disturbance change, heavily affecting Mediterranean areas but also increasingly impacting temperate and boreal regions. Bark beetle infestations will increase particularly in the temperate biome in response to warmer temperatures and droughts. These projected changes will alter the structure and demography of Europe's forests considerably increasing young forests and reducing old forests.

Please note that management was assumed to continue without adapting to climate change and increased disturbance risks in order to isolate the effect of climate change on forest disturbance regimes. Also, high uncertainty remains regarding future changes in wind extremes; hence the study assumed the frequency and severity of extreme winds to remain at historical levels.

What could policymakers do?

1. Consider expected changes in future forest disturbances in European and national policies on future forest carbon storage, timber markets, biodiversity, and the transition to a bioeconomy.
2. Mainstream disturbance risk management into forest planning based on integrated disturbance management strategies at pan-European, regional, and local levels.
3. Support trans-continental disturbance monitoring and management, sharing information and resources towards early warning systems and efficient disturbance response strategies.
4. Support heterogeneity in post-disturbance forest development and the initiation of mixed and structurally diverse forests of climate-adapted tree species to foster future forest resilience, e.g., by reducing legal constraints in post-disturbance management and targeted subsidy programs.
5. Fund research into the causes and consequences of changing forest disturbance regimes to support evidence-based decision making.
6. Emphasise rapid GHG emissions reduction to prevent worst case climate change scenarios which lead to much more extreme future disturbances.

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