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Abrupt increase in harvested forest area over Europe after 2015

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Abstract

Forests provide a series of ecosystem services that are crucial to our society. In the European Union (EU), forests account for approximately 38% of the total land surface¹. These forests are important carbon sinks, and their conservation efforts are vital for the EU's vision of achieving climate neutrality by 2050². However, the increasing demand for forest services and products, driven by the bioeconomy, poses challenges for sustainable forest management. Here we use fine-scale satellite data to observe an increase in the harvested forest area (49 per cent) and an increase in biomass loss (69 per cent) over Europe for the period of 2016–2018 relative to 2011–2015, with large losses occurring on the Iberian Peninsula and in the Nordic and Baltic countries. Satellite imagery further reveals that the average patch size of harvested area increased by 34 per cent across Europe, with potential effects on biodiversity, soil erosion and water regulation. The increase in the rate of forest harvest is the result of the recent expansion of wood markets, as

suggested by econometric indicators on forestry, wood-based bioenergy and international trade. If such a high rate of forest harvest continues, the post-2020 EU vision of forest-based climate mitigation may be hampered, and the additional carbon losses from forests would require extra emission reductions in other sectors in order to reach climate neutrality by 2050³.

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Data availability

To ensure full reproducibility and transparency of our research, we provide all of the data analysed during the current study. The data are permanently and publicly available on a Zenodo repository, <https://doi.org/10.5281/zenodo.3687090>.

Code availability

To ensure full reproducibility and transparency of our research, we provide all of the scripts used in our analysis. Codes used for this study (Google Earth Engine and R scripts, the harvest-removals dataset and shapefiles of the validation) are permanently and publicly available on a Zenodo repository, <https://doi.org/10.5281/zenodo.3687096>.

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Contributions

G.C. and A.C. conceived the idea and designed the methodology; G.C. analysed the data and wrote the Google Earth Engine and R scripts; G.C. and A.C. wrote the manuscript with contributions from G.D., G.L., V.A., R.P. and G.G.. All authors contributed critically to the interpretation of the results and gave final approval for publication.

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Ethics declarations

Competing interests

The authors declare no competing interests.

Additional information

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Extended data figures and tables

Extended Data Fig. 1 From tree cover to forest cover.

a, Tree-cover threshold needed to define a forest (colours) and percentage error between FAOSTAT-2015 and remote-sensing-based forests (labels). **b**, Forest threshold sensitivity. Maps were generated using GEE²².

Extended Data Fig. 2 Verification of EU forest area.

a, GFC data versus FAOSTAT for 2000 and 2010. **b**, GFC data versus LUCAS for 2009, 2012 and 2015.

Extended Data Fig. 3 Validation of GFC-derived forest loss with high-resolution data.

a, b, Validation of the classification of harvested areas in the years 2012 and 2017 by forest patches of sizes small (≤ 0.27 ha) and large (> 0.27 ha and ≤ 4.5 ha; **a**), and big (> 4.5 ha; **b**). **c**, Accuracy of harvest area derived from GFC-derived forest loss versus patch size (labels and circle size refer to the EU26-wise cumulative harvested forest).

Extended Data Fig. 4 Harvested forest area by forest type.

Time series of land cover type (from GlobCover)²⁵ for EU26. Colours refer to the three forest types: mixed, broadleaf and needleleaf.

Extended Data Fig. 5 Harvested forest area components.

a, b, Annual distribution of harvested forest for different classes of patch size, ranging from small patches (harvested forest area less than 0.27 ha) to big patches (harvested forest area greater than 7.2 ha) for all of EU26 (**a**), each EU26 country (**b**).

Extended Data Fig. 6 GFC-derived harvested forest area versus official harvest removal data.

Harvested forest area from the GFC maps (red bars, normalized between 0 and 1) and volumes of harvest removals from national statistics (black lines, normalized between 0 and 1). We excluded areas affected by forest fires and retained areas affected by major windstorms because they appear in the harvest removal data. Statistical significance at $P = 0.05$ for remote sensing and national statistics is indicated by an asterisk and a hash, respectively, in the country label panels. The value in brackets is the correlation coefficient, r . Maximum values of harvested forest area and official

harvest removal data for each country are reported in the second and third lines of each label, respectively.

Extended Data Fig. 7 Harvested forest area versus Eurostat³² economic aggregates.

Harvested forest area from the GFC maps (red bars, normalized between 0 and 1) and volumes of economic aggregates of forestry from Eurostat data (black lines, normalized between 0 and 1). We excluded areas affected by forest fires and retained areas affected by major windstorms because they appear in the harvest removal data. Percentages in the first and second brackets after the country label refer to the percentage change 2008–2016 (or 2012–2016 when 2008 records are not available) of remote sensing and market value, respectively. Maximum values of harvested forest area and volumes of economic aggregates of forestry for each country are reported in the second and third lines of each label, respectively.

Extended Data Fig. 8 Harvested forest biomass per year.

Percentage of AGB harvested (expressed as relative amount of biomass affected by management practices) per year in a 0.2° grid cell excluding forest losses due to fires and major windstorms and areas with sparse forest cover. As in Fig. 1 but measuring biomass instead. This map was generated using GEE²².

Extended Data Fig. 9 Cloud-free land coverage of Landsat in Europe.

a, Time series of cloud-free Landsat scenes (cloud cover less than 20%) for EU26. **b**, Spatial distribution of cloud-free Landsat images over Europe. Grey areas indicate where no data was available for the selected year using satellite imagery. Map and time series were generated using GEE²².

Extended Data Fig. 10 Growth rates of forest biomass.

a, b, Relative (**a**) and absolute (**b**) growth rate of forest biomass as derived from the *State of Europe's Forests 2015* report¹ in combination with GlobBiomass²⁷ and GFC²¹ data. The data in **a** are given over five European regions, with colours corresponding to the colour scale: north (yellow), central west (green), central east (lime), south west (purple) and south east (blue). Maps were generated using GEE²².