Recent and abrupt increase in forest harvesting in Europe

Key messages

A new study (Ceccherini *et al.*, 2020[1]) reported a recent and abrupt increase in the forest area and biomass harvested in the EU

Fifteen years of high-resolution satellite observations revealed a large increase (+49%) of the area of forest harvested with clear-cuts in Europe in recent years (2016-2018), relative to the period 2011-2015. When associated with a biomass map, this increase in area corresponds to a 69% increase in biomass harvested during the same period. These trends are mostly due to an intensification of management, since salvage logging after forest fires and windstorms is factored out.

Where, how and which forests are harvested

About 80% of the increase in the EU forest harvested area with clear-cuts in 2016-2018 is located in seven Member States: Sweden (29%), Finland (22%), Poland (9%), France (6%), Latvia (4%), Germany (4%) and Spain (4%). Harvesting occurs mostly in large patches (i.e. greater than 7.2 hectares). Overall, the patch size has recently increased by 34% across the EU. Needleleaf forests account for half of the total EU harvest and the recent increase in harvest rates.

Drivers of change

The possible drivers of the current increase in the forest harvested area and biomass include:
1) the growing share of forests used for wood production which are reaching harvesting maturity, 2) an increase in the forest area affected by unaccounted natural disturbances (e.g. bark-beetle outbreaks), and 3) the recent expansion of the wood markets, as shown by econometric indicators on forestry, wood-based economy and international trade.
According to our analysis, socio-economic and political factors are likely the most probable drivers, even if a causal connection is difficult to prove and quantify.

Key Questions

How can forest monitoring be advanced to support a sustainable course for European forests?

Forests provide a series of ecosystem services that are crucial to society: climate mitigation, water supply and regulation, timber production, bioenergy, biodiversity conservation, clean air, erosion control, etc. The European Green Deal commits the EU to improving its forested area, both in quality and quantity, and to fighting global deforestation linked to the EU's footprint. In the European Union (EU), forests account for approximately 40% of the total land surface[2]. These ecosystems are important carbon sinks, and their conservation, in the frame of a sustainable bioeconomy, are key for the EU's vision of becoming the world's first carbon-neutral continent by 2050[3].

However, the increasing pressure on forest services and products poses new challenges to sustainable forest management. An increase in the intensity of wood harvesting can stimulate the wood-based economy, increase the amount of carbon stored in long-lived harvested wood products, and substitute fossil fuel energy and other materials (e.g. cement, steel). On the other hand, it may affect the carbon sink and impact on other ecosystem services, such as the conservation of biodiversity, soils, and water resources. To minimize these trade-offs, in 2018 the European Bioeconomy Strategy defined clear targets of sustainability, circularity and the protection of EU natural resources[4].

The comprehensive assessment of trade-offs requires timely and accurate monitoring of forest management intensity. Efforts to track changes in forest cover and forest harvesting in the EU are hugely important for improving our understanding of the status of European forests and habitats, as well as carbon mitigation and fossil fuel substitution potentials. It also provides valuable groundtruthing of National Forest Inventories, crucial near-real-time information that is increasingly spatially explicit, and complements forest modelling activities that can altogether improve the monitoring of the EU wood budget. For example, in Europe, almost 13% of the harvested forest biomass is currently not accounted for in official statistics (i.e. 'unaccounted sources'), thus confounding the planning and optimisation of this resource[5].

Nowadays, the combination of increasingly available high-resolution satellite records (e.g. from Landsat and Copernicus platforms, Fig. 1) and cloud-computing infrastructures, provides novel methods to forest monitoring that are independent from official country reporting.

Complementing national forest inventories with Earth observations has several benefits:

i) it increases transparency, as governments, industries and the general public can better track forest resources;

ii) it supports the geographically explicit calculation of greenhouse gas emissions and removals, as required in recent EU land-related legislation[6] ;

iii) it offers near-real-time information, supporting early warnings and timely policy responses;

iv) it complements official statistics with independent and consistent continental scale assessments.

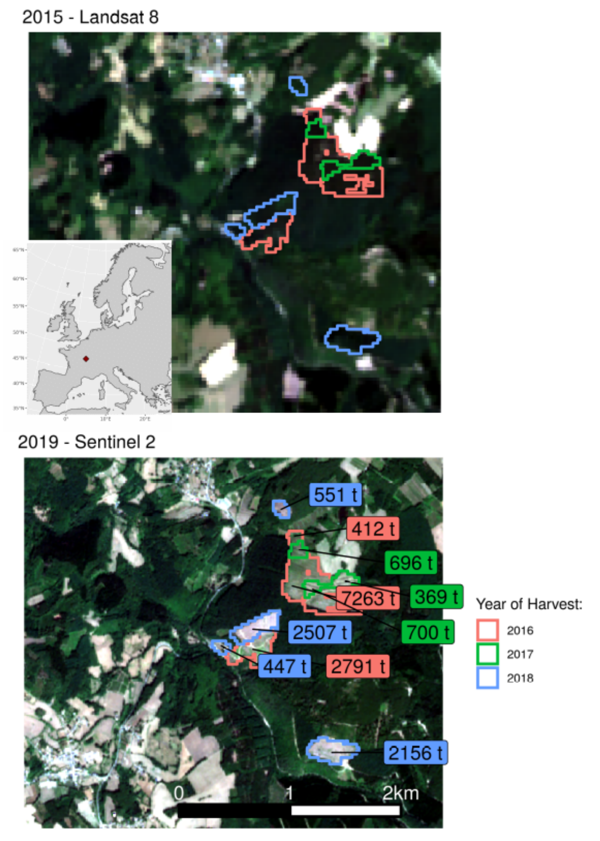

Fig. 1. ***Examples of forest harvest detection from remote sensing imagery.*** *Distribution of harvest polygons derived from the global forest watch project for a location in France. The top panel refers to 2015 when only Landsat 8 data, with 30 m spatial resolution, was available. The bottom panel refers to 2019 when the new Copernicus Sentinel-2, with 10 m spatial resolution, was available. The numbers in the bottom panel refer to the estimated forest biomass loss (tonnes of dry matter) derived from a biomass map [7].*

An advanced monitoring capacity that exploits the potential of satellite observations could respond to the increasing demand of timely, spatially explicit and robust forest data, e.g. under the planned EU Observatory on deforestation and forest degradation. The combination of high spatial resolution satellite imagery with big-data analytics has great potential to enhance EU and global forest monitoring, to inform forest policies at local, national and international scales, and help track both economic and environmental progress towards sustainable growth. These novel approaches to the monitoring of forest resources will help identify and assess the trade-offs (i.e. economic versus ecological services) arising from increasing pressure on EU forests. In addition, they will support the design and implementation of forest-related policies under the Bioeconomy Strategy[4], the European Green Deal, the upcoming new Forest Strategy, as well as the greenhouse gas reporting needs under the Paris Agreement.

How much forest biomass is harvested in the European Union?

According to the latest available data[1], the harvest intensity in clear-cuts (i.e the percentage of forest area harvested with clear-cuts per year) was rather stable across most European countries from 2004 to 2015 (Fig. 2). Conversely, for the years 2016-2018 we observed a sudden increase in large parts of the EU, particularly in the Nordic and Baltic countries, and in the western part of the Iberian Peninsula. The annual forest area harvested during the period 2016-2018 increased by 49% compared to 2011-2015.

The assessment of the forest harvest was also quantified in terms of biomass harvested over the 2011-2018 period; this shows an even greater increase in recent years (+69% compared to 2011-2015, Fig. 3). This striking rise in harvested forest area and biomass is particularly marked in countries (e.g. Sweden, Finland, Poland, France, Latvia, Portugal, and Estonia) that have strong economic activities in the forestry sector (e.g. bio-energy sector, paper industries). The greatest increase in harvested forest biomass in 2016-2018 in 26 EU countries was recorded in Sweden and Finland, which together accounted for more than 50% of the total increase in harvested biomass observed in recent years. Poland, France, Latvia, Germany and Spain accounted for about 30%.

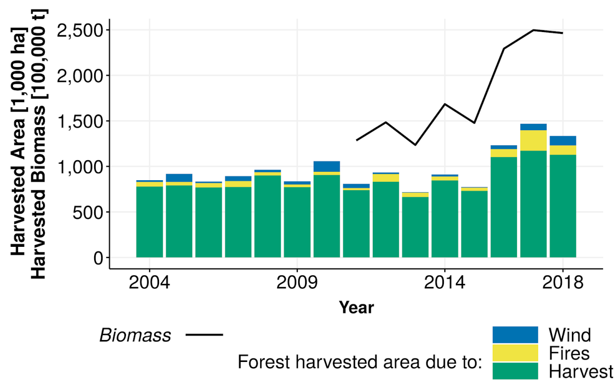

Fig. 2. ***Temporal trends in EU forest harvest*** *[1]. Time series of the total area and biomass harvested in the European domain (EU-26, which excludes Cyprus and Malta) due to forest fires, major windstorms and forestry.*

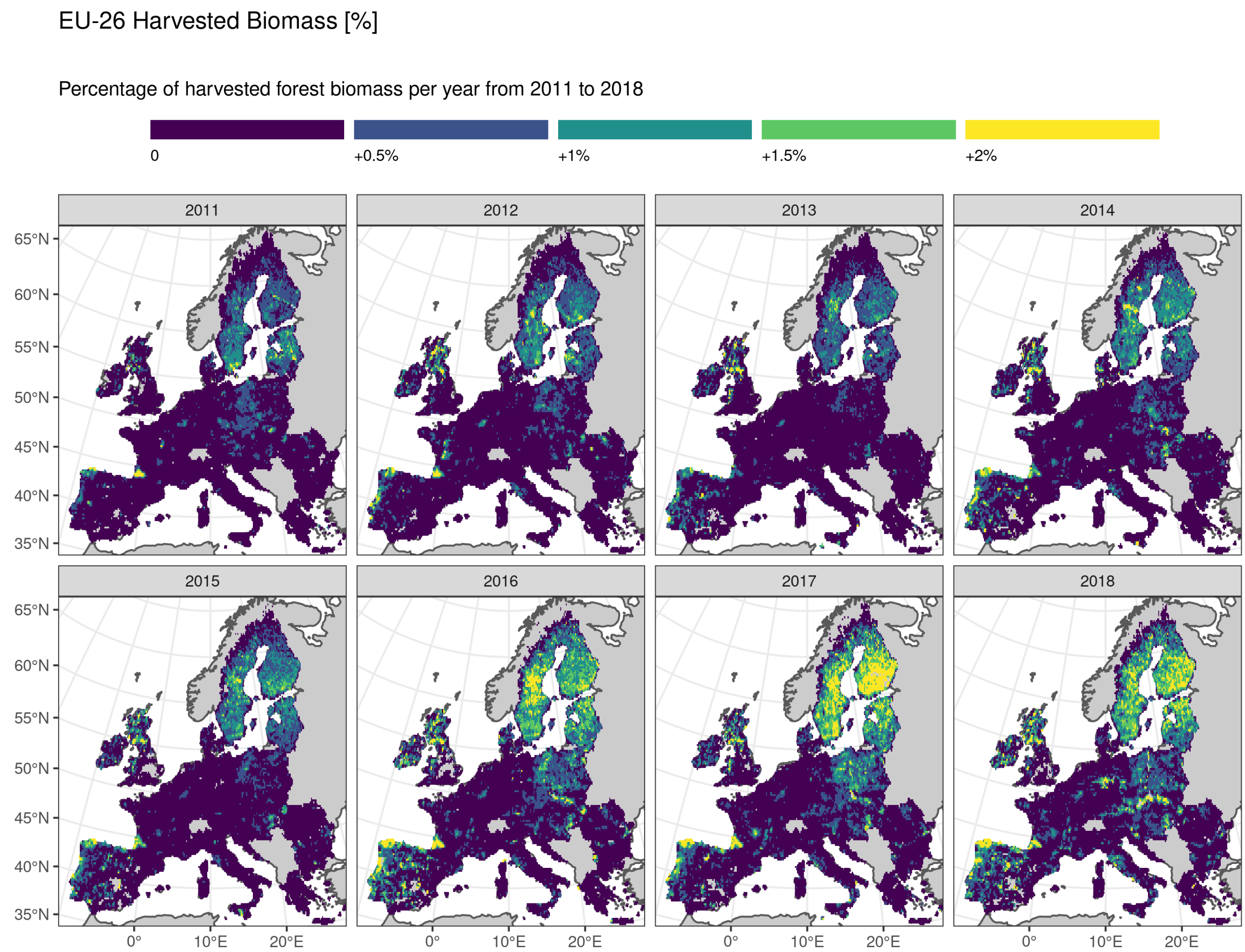

***Fig. 3. Harvested forest biomass per year*[1]** *. Percentage of harvested forest biomass per year in a 0.2° grid cell (about 20km), excluding areas with sparse forest cover and forest losses due to fires and major windstorms.*

Although the relatively high percentage of mature forests in various parts of the EU is expected to drive a moderate increase in the harvest rate, the magnitude and speed of change observed in 2016-2018 rather suggests an increase in demand for wood and/or a change in forest policy. This striking increase in management intensity is also combined with an increase in forest losses due to natural disturbances from fires and windstorms, which were however factored out of the harvest statistics reported above. An exceptional number of fires (~ 210% increase) were detected for the years 2016-2018 compared with the average number of fires observed during the 2004–2015 period (Fig. 2). In addition, there was an increase in major windstorms in the order of 90% for the years 2016-2018 compared to the average of windstorms observed during the 2004–2015 period. This is particularly marked for 2018. However, areas hit in 2016-2017 are generally smaller than in 2005, 2007 and 2010. In addition, in recent years bark-beetles infestations have increased in several European countries (e.g. Slovenia, Slovakia, Germany, Czech Republic). Due to the lack of Europe-wide data on the occurrence of insect outbreaks, it was not possible to assess the effect of these disturbances on harvest rates.

Which forests contribute most to harvested biomass?

Needleleaf forests account for more than 50% of the detected harvested area in the 26 EU countries, followed by mixed and broadleaf forests, in accordance with the Eurostat report[8] (Fig. 4).

The largest increase in harvested area occurred in stands with more than 50 t/ha of biomass, whose economic value is likely the principal motivation for the harvest (economic driver). Patterns of harvested forests in biomass classes differ between countries, reflecting the variability of forest types and management strategies in Europe. For instance, most of the harvesting in Finland and Sweden occurred in needleleaf forests in the range 50-150 t/ha. Conversely, Poland and Italy show maximum harvest rates in stands with greater biomass levels (i.e. 100-200 t/ha) in mixed and broadleaf forests, respectively[1].

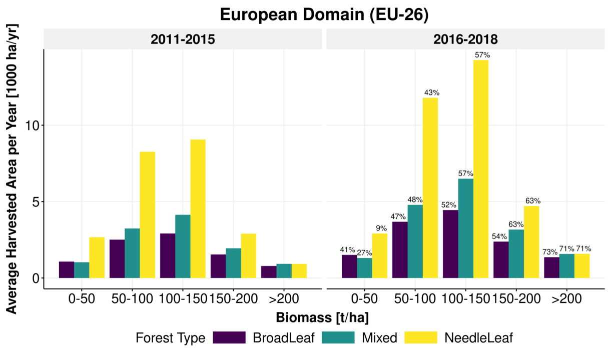

*Fig. 4. **Trends in forest harvesting**[1]. Average harvested area for five biomass classes for the period 2011-2015 (left panel) and 2016-2018 (right panel) for the European domain. Colours refer to the three forest types. Labels over the bars in the right panel show the percentage variation in 2016-2018 compared with the reference period 2011-2015 for each biomass class.*

The size of harvest patches depends on the topography and silvicultural practices of the country, with larger patches in the case of clear-cuts (more common in Scandinavian countries, the UK and Ireland) and smaller gaps for group selection and shelterwood systems (common in central or southern Europe). The patch size is a relevant feature of forest management since it may affect the provision of ecosystem services: generally, larger patches have stronger impacts on ecosystems through habitat disruption, soil erosion, and increased water runoff. Satellite observations reveal that the overall gap size has recently increased by 38% across the EU. Such an increase occurred mostly in large forest patches (> 7.2 ha)[1]. In 21 out of 26 EU countries, the size of harvested patches has increased by more than 49% in recent years. Portugal and Italy exhibit an abrupt rise in the average gap size for the period 2016-2018 compared with 2004-2015 (more than 100%).

Why is the forest harvest increasing?

There are several potential reasons for the recent increase in the forest harvested with clear-cuts: the growing share of EU forests reaching harvesting maturity, an increase in salvage logging due to natural disturbances not fully unaccounted in our assessment (e.g. diffused bark-beetle infestations) that might have increased the share of clear-cuts in forest harvesting operations, and socio-economic drivers such as changes in the political context and/or in the market demand for wood products.

Harvest volumes are expected to increase because of the growing share of EU forests used for wood production which are reaching harvesting maturity[9]. However, according to the most recent statistics, this cannot explain more than 10% of the observed recent increase in harvested area[1]. Moreover, the abrupt increase in harvesting detected from satellite records in 2016 is not coherent with the gradual trend expected from the ageing effect. Natural disturbances (i.e forest fires, salvage logging after major windstorms) in Europe have had a big impact on inter-annual variations during the past decade, but these have not affected the recent trend. At present, the limited availability of data does not allow to draw a conclusion about the role of bark-beetle infestations on the harvest trends. However, we acknowledge that the occurrence of natural disturbances may have increased the share of clear-cuts (which are accounted in this study) and, for compensation, decreased the share of small-scale management (e.g. selective logging, not detected from satellite). Unfortunately, we cannot estimate the magnitude of the potential shift between small- to large-scale harvesting on the statistics.

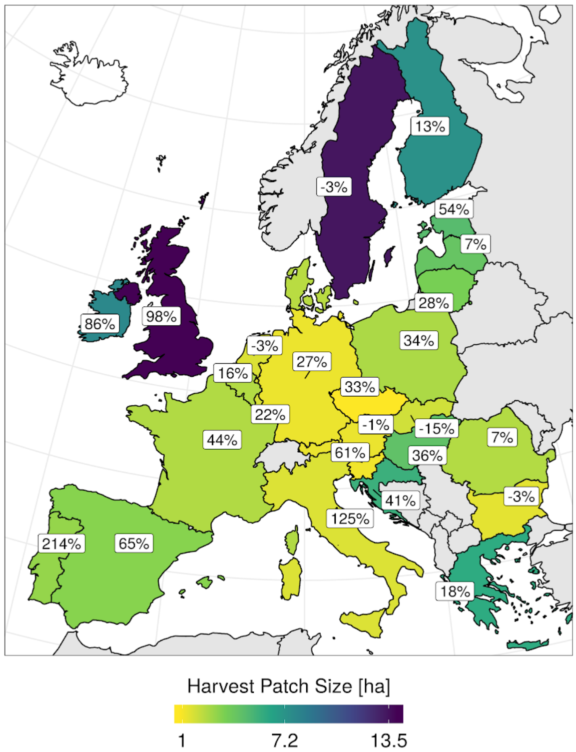

*Fig. 5. **Country average harvest patch size and its recent change** [1]. Average harvest patch size and percentage variation in size for the year 2016-2018 compared with 2004-2015.*

Ultimately, changes in socio-economic and political factors are a further possible drivers, even if a causal connection is difficult to prove and quantify[10]. Whereas the reaction of the harvest rate to a socio-economic stimulus or policy may vary from one country to another (including country-specific import/export patterns), all economic indicators of wood demand and market (i.e. FAOSTAT, Eurostat, and UNECE) confirm a substantial expansion of the forest sector in recent years. For example, the output from forestry and connected secondary activities (Fig. 6) increased by 25% in the EU-28 from 2012 to 2016 according to the recently updated EUROSTAT report. This is possibly linked to new legislation promoting the use of wood for material and energy substitution[11]. It is important to note that the increase in harvest concerns 2016-2018, and this confirms the wisdom of the updated EU Bioeconomy Strategy (2018)[4], which puts circularity and sustainability at its core, with one of the three priorities for actions on "protecting ecosystems and understanding the ecological limitations of the bioeconomy".

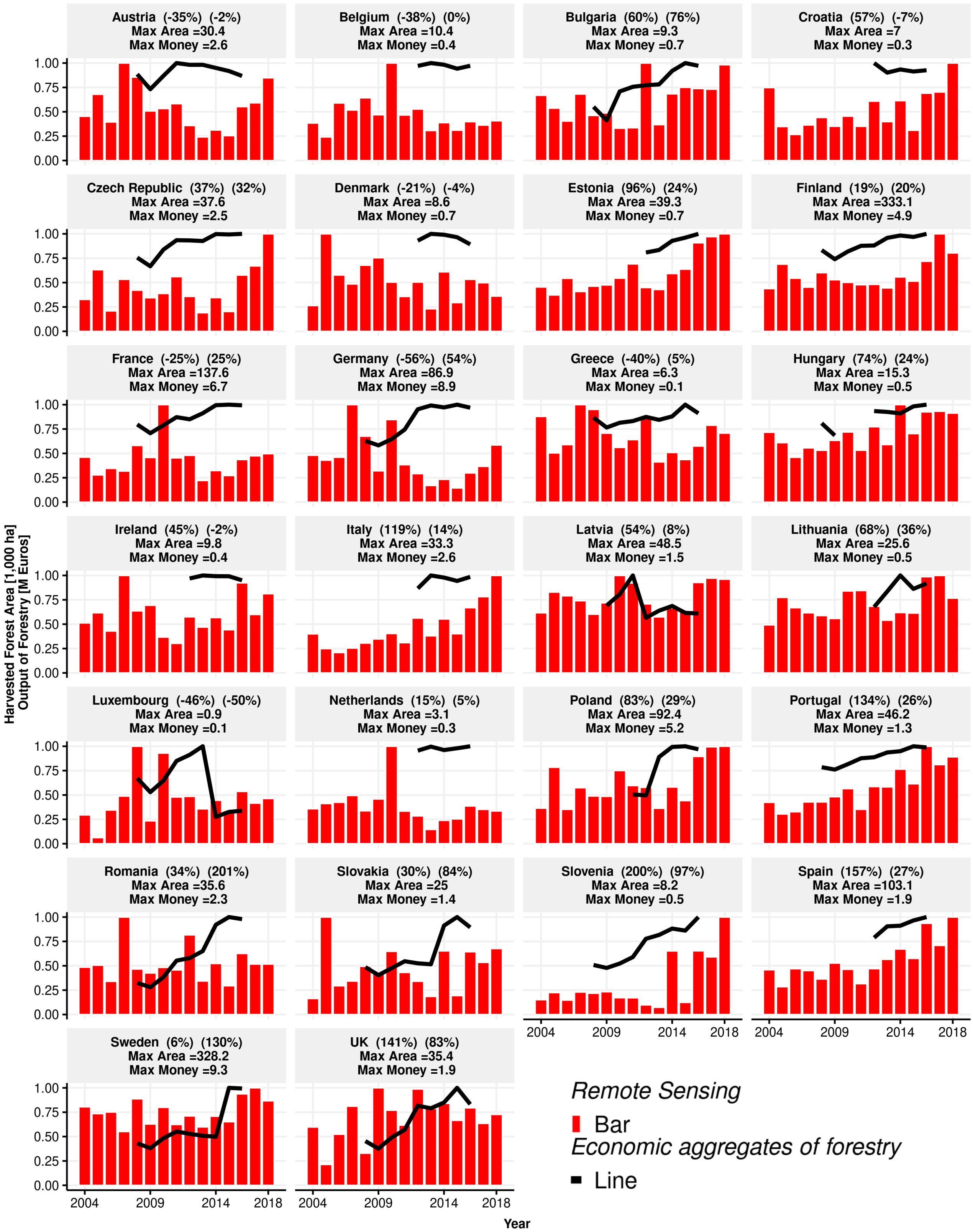

Fig. 6. ***Time series of harvested forest area and Eurostat Economic Aggregates*** *[1]. Harvested forest area from remote sensing (bars, normalised between 0 and 1) and volumes of economic aggregates for the forest sector from Eurostat (lines, normalised between 0 and 1). Forest fires are excluded, while major windstorms are included because they appear in the harvest removals. Percentages in brackets 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.*

Fig. 7. Total international exports of wood [m³] [1] from the EU-26.

International trade (Fig. 7), sometimes linked to political factors, may also affect the harvest demand at the national level. This was, for example, the case for some North European countries (i.e. Finland and Estonia), where the collapse of exports of roundwood from Russia since 2009 also indirectly affected the internal harvest demand. On the other hand, in some Central European countries (i.e. Czechia, Hungary and Slovenia), exports have greatly increased since 2014, encouraged by the increasing demand for roundwood from Germany (where imports increased by 30% since 2014), from some other EU countries (i.e. UK and Croatia) and, more recently, from China[1].

Methods

Data of temporal changes in forest area across 26 EU countries were derived from the Global Forest Change layer[12], a map product that provides estimates of tree cover area, gains and losses from 2001 until 2018. Tree cover information has been converted into forest cover based on an optimisation algorithm that accounts for the country-specific definition of forest areas. Losses due to forest fires and major windstorms are factored out, and the remaining variation in forest cover was attributed to forest management. Thanks to the spatial resolution of the underlying satellite data, the Global Forest Change dataset is sensitive to clear-cut areas (larger than about 1000 m²), whereas small-scale operations such as thinnings and selective logging cannot be detected.

Data analysis was performed using Google Earth Engine[13], a big-data Earth-observation platform that allows for seamless parallel computing and geospatial operations. This platform supports the calculation of pixel-level or country-level statistics based on the entire records of the Global Forest Change dataset, as well as ancillary land cover data with high computational efficiency. Visual validation using a sample of high spatial resolution imagery confirmed the accuracy of our methods to detect forest harvest, even though uncertainties are lower for large patches (i.e. when the patch size is greater than 0.27 hectares) than in fragmented ones (i.e. when the size is less than 0.27 hectares). Together, these new methodologies and datasets represent key assets for the implementation of the European Green Deal, the achievement of climate neutrality and the sustainable management of European forests, in accordance with the goal of the sustainable and circular EU Bioeconomy Strategy[4].

Knowledge gaps

Remote sensing imagery cannot reliably capture small-scale harvest operations (e.g. single tree selective logging), when the area is smaller than the sensor's spatial resolution (i.e. 30 m for Landsat). Our estimates therefore refer to clear-cuts larger than about 0.1 ha for the estimation of harvested areas and 0.2 ha for the size of harvest patches. In addition, changes that occur below the canopy top (e.g. thinnings) cannot be detected by satellite optical sensors, potentially leading to an underestimation of actual harvested biomass. Future assessments based on Sentinel-2 will likely improve the accuracy of the estimates thanks to the advancements in temporal and spatial resolution.

On the other hand, National Forest Inventories use country-specific definitions and methodologies, and are infrequently updated and potentially incomplete. Similarly, statistics from the FAO and Eurostat on forest harvesting are incomplete and not detailed for some countries, years and connected economic activities. These traditional surface-based statistics could be effectively complemented with satellite-based estimates.

Uncertainties related to the drivers of forest harvest estimates are relatively large. The causal connection between harvest rate and its drivers is difficult to prove and quantify. In fact, changes in the harvest due to a socio-economic stimulus or to land-based policies may vary from one country to another.

Finally, there are uncertainties in the attribution of natural forest disturbances to various drivers (e.g. fires, insects' outbreaks, windthrow, etc), that should be improved with advances in methods and sensors.

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