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Climate-driven increases in wildfire projected to affect European forest types differently

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**Abstract**

Climate change is expected to increase the frequency and size of large uncontrollable fires. The impact of this trend on forest vegetation is still poorly understood, especially in areas not commonly subject to recurrent fires, i.e. in areas where tree species may not be adapted to fire and where flammability may increase as warming decreases moisture. Here we use recent advances in remote sensing to simulate burned area development until the end of the century under different climate scenarios. We then combine these projections with an European forest resources model to assess the impact of projected fire regimes on forests in three major biomes in Europe (i.e. Mediterranean, temperate and boreal forests, here represented by three countries: Spain, Germany and Sweden). Burned area was projected to increase in all regions in the 21st century, with the biggest increase and highest absolute damage in the Mediterranean region under the most severe climate scenario. Furthermore, we found that future fire disproportionately affects temperate forests, where a higher level of damage occurs for the same relative increase in burned area, compared to the other biomes. This was mostly due to the combination of increasingly favourable weather conditions for fire and large standing biomass, which drove the increased susceptibility of temperate regions to emerging wildfire regimes. Our findings call for mainstreaming fire and fuel management strategies into forest planning to increase resilience to fires, particularly in temperate regions with limited past fire occurrence and a projected increase in favourable fire weather.

1. Introduction

Current human-induced global temperature increase affects forest wildfire regimes in different ways. The reduced atmospheric humidity due to rising temperatures increasingly creates more extreme (Jain *et al*

2022) and compound drought events (Richardson *et al* 2022). On the one hand, recurring droughts negatively affect the vitality and health of forests directly (Peñuelas *et al* 2017). On the other hand, droughts reduce the moisture content of dead biomass, increasing the chances of ignition and burning of forests

(Ellis *et al* 2022). The disturbance-induced reduction of forest productivity (Van Der Woude *et al* 2023) and increased burned area (BA; Nolan *et al* 2020, Jones *et al* 2022) in turn hamper forests' ability to absorb carbon and mitigate climate change (Pugh *et al* 2019).

Despite its recent global increase, forest BA in Europe has been stable over the last decades (San-Miguel-Ayanz *et al* 2023), and even decreased in some regions (Urbieto *et al* 2019). Those trends are due to a wealth of fire prevention knowledge and prompt detection, intervention and suppression strategies in Europe (Turco *et al* 2016). However, while BA has been stable, in the last few years a shift in fire behaviour was observed (Patacca *et al* 2023), where the decrease of BA by average fires is offset by few very large fire events (as also asserted by the 2025 fire season). Those large wildfires happen when a combination of factors (i.e. ignitions, continuous fuel loads, severe fire weather) leads to extreme intensity and spread rates of fires, hampering suppression efforts (Pausas and Keeley 2021). Size and severity of fires in Europe are directly connected to increasing aridity (Grünig *et al* 2023), which—in turn—is driven by rising temperatures, suggesting that large fires might soon revert the currently stable trend of BA across Europe.

Although forest BA in Europe is expected to increase with climate change (Grünig *et al* 2023, 2025), the impacts of fire on tree mortality remain highly uncertain. Historically, fires are assessed in terms of number of events and BA, expressed in hectares (San-Miguel-Ayanz *et al* 2013), with reporting greatly facilitated by technological developments in satellite remote sensing (Senf and Seidl 2021a). Albeit valuable for understanding fire regime trends, spatial information is difficult to apply when assessing the direct impact of fires on forest vegetation. This is because the relationship of fire-induced mortality with BA is non-linear across vegetation types (Vallet *et al* 2023) and depends on forest features which are difficult to assess from remote sensing products, especially where fire damage has historically been rare. On the one hand, the impact of fire on trees is shaped by species' evolutionary adaptations to fire, as species from fire-prone regions have developed functional traits that enhance survival and regeneration (Keeley and Pausas 2022). On the other hand, it also depends on forest stand density and structure, which in Europe are largely influenced by historical management practices (Suvanto *et al* 2025). Given the large functional and structural differences of forests across Europe, an increase in BA in the Mediterranean (where forests are well adapted to fire and stocking levels are lower) might cause less tree mortality compared to the same relative BA increase in a temperate or boreal forests. In light of these considerations, we hypothesised that future wildfire regimes driven by climate change will

result in disproportionate tree mortality in temperate and boreal forests compared to Mediterranean forests.

To test this hypothesis, we integrated remotely-sensed fire data with global climate models to project future forest BA across Europe. We then combined these projections with the European forest resources simulation model EFISCEN-Space (Nabuurs *et al* 2007, Schelhaas *et al* 2022) which integrates functional and structural forest characteristics to project future fire-induced tree mortality across different biogeographical regions of Europe.

2. Materials and methods

This study focuses on three European countries: Spain, Germany and Sweden, that represent the three main forest biomes in Europe: Mediterranean, Temperate, Boreal (Olson *et al* 2001). These biomes have historically experienced different fire regimes (Galizia *et al* 2022), which shaped forest vegetation in different ways.

2.1. Forest resource model—EFISCEN-Space 1.2

We employed the forest resource model EFISCEN-Space to simulate forest dynamics at the stand scale. The model is initialised with plot and tree level National Forest Inventories (NFIs) data (table S1), which report forest structure and species composition at a certain moment in time. A forest stand can be composed of different cohorts. A cohort is composed of trees of the same species group that are in the same diameter at breast height (dbh) class. Forty dbh-classes of 2.5 cm class width are specified for 20 different tree species groups in the model (table S2). The development of the forest state is then simulated at a 1 year time-step as the change of stem density per species group in each dbh cohort. Tree growth is expressed as the annual dbh increment for a given species and size, influenced by stand characteristics (e.g. density) and environmental factors (e.g. climate, soil) following Schelhaas *et al* (2018a). Also tree mortality, ingrowth and harvest are simulated at every time step (Schelhaas *et al* 2022, König *et al* 2025). Forest management regimes are defined by a set of rules that trigger a harvest event when a forest characteristic threshold is exceeded. Those rules are informed by tree species, diameter class, stand basal area, as well as stem density and define final felling and thinning regimes by determining cutting probability and intensity. Furthermore, rules are specified by country and biogeographical region (Feliciano *et al* 2025) and are parameterised based on a large set of remeasured NFI plots. EFISCEN-Space biomass estimates are derived from species-specific allometric equations (Forrester *et al* 2017), with parameters per tree compartments available for most European

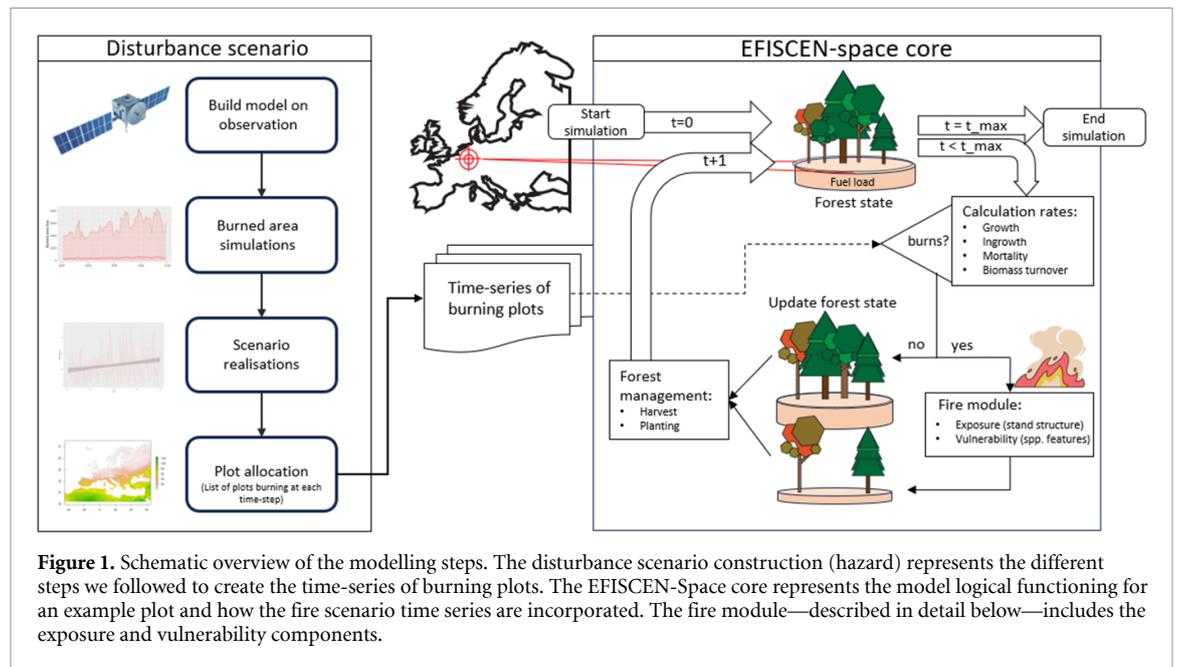


Figure 1. Schematic overview of the modelling steps. The disturbance scenario construction (hazard) represents the different steps we followed to create the time-series of burning plots. The EFISCEN-Space core represents the model logical functioning for an example plot and how the fire scenario time series are incorporated. The fire module—described in detail below—includes the exposure and vulnerability components.

species as well as species groups such as conifers and broadleaves. As for wood density, EFISCEN-Space uses default values from the IPCC (Penman *et al* 2003). Biomass is divided into four compartments: stem, roots, branches and foliage, with values estimated based on dbh. Total biomass per compartment is calculated by multiplying the number of trees by the estimated biomass of the average tree in each species-diameter class (Schelhaas *et al* 2022).

2.2. Disturbance modelling approach

Disturbance modelling in EFISCEN-Space consists of three components: hazard, exposure, and vulnerability. Hazard is represented by externally constructed disturbance scenarios—time series indicating when a stand is affected by disturbance—allowing flexibility across climate forcings and scenario-construction methods. Exposure refers to stand structure and fuel load at the time of disturbance, while vulnerability reflects species traits that determine disturbance impacts and responses (Barrere *et al* 2023). Exposure and vulnerability are assessed at each time step by the fire disturbance module to determine forest damage. We here define forest damage as the amount of forest standing stem wood affected by disturbances. The modelling follows a multistep approach: constructing disturbance scenarios and then simulating their impacts in EFISCEN-Space (figure 1).

2.3. Disturbance scenarios

To model BA scenarios, we first assessed the historical fire occurrence records derived from a remote sensing-based European disturbance map at a spatial grain of $30 \times 30 \text{ m}^2$ or 0.18 ha (Senf and Seidl 2021a, 2021b). We aggregated all the recorded fire disturbance patches to fire complexes. Patches within a

proximity of 150 m were merged into single fire complexes, avoiding the artificial split of large fires by fire breaks or roads. A convex hull was then drawn around each complex to calculate its total area. This aggregation process resulted in yearly fire complexes from 1986 to 2020, from which we aggregated annual BA per country. In a second step, we fitted statistical models to capture the sensitivity of the remotely-sensed BA to summer aridity, which was found to be a good predictor of fire activity at large scales (Turco *et al* 2017, 2018, Ruffault *et al* 2020). We modelled BA scenarios following the approach of Grünig *et al* (2023), and summarise the essence of the approach here for clarity. We used ERA-Land monthly average climate data (1986–2020) to calculate summer vapour pressure deficit (VPD_s) as aridity index and calculated yearly averages across countries. We calibrated Bayesian hierarchical models (*brms*, Bürkner 2017), with BA as dependent and VPD_s as independent variable and countries nested in biomes as random effects. We simulated 4000 random posterior draws of BA per country, under historical and future climates, and calculated annual medians and 95% credible interval (figures S1 and S2). We then compared predicted historical distributions with European burned area statistics (mapped at spatial grain of 30 ha, San-Miguel-Ayanz *et al* 2023, figure S1). For future climate data, we used two global climate models (GCMs): EC-EARTH (Consortium (ECEarth) 2017a, 2017b, 2017c) and MPI-ESM1-2-LR (Mauritsen *et al* 2019), to represent climate model uncertainty for the European region (figure S3), and their average, for three relative concentration pathways (RCPs): RCP-2.6, RCP-4.5 and RCP-8.5. We used the GCMs average to test the sensitivity of averaging climate data before EFISCEN-Space forest dynamic runs. In future simulations, we randomly sampled for each country

and year an amount of BA from the simulated ranges (median and 95% CI, figure S2). This process was carried out 5 times for each GCM-RCP combination. We then selected which NFI plot to burn for each country and year. NFI plots are representative for a certain forest area, depending on the country's NFI design (table S1). We allocated the simulated BA to plots, until their representative area met the BA simulated in that year and country. Plot allocation was based on the mean Canadian Fire Weather Index (FWI; Wagner 1987) over the European fire season (June–September) to select which plot was more likely to burn. The FWI index is a non-dimensional rating of fire potential based on meteorological conditions favourable to the start, spread and persistence of fires. The FWI's projections in the future (version 2.0, resolution $0.11^\circ \times 0.11^\circ$) were derived from ERA5 reanalysis produced with the same GCMs employed for climate simulations (Bedia *et al* 2018). Data was downloaded from the Copernicus Climate Change Service, Climate Data Store (2020). Plots were ranked by FWI, and burning was allocated until the annual BA target was met. Because all plots within a $0.11^\circ \times 0.11^\circ$ FWI grid cell ($\sim 121 \text{ km}^2$) share the same value, BA allocation would be biased towards the first alphabetically-ordered plots in the grid cell. To mitigate this artefact, and reduce unrealistic returns of those plots, we introduced a random factor (-0.1 to 0.1) to each plot's FWI.

2.4. Fire impact module

Fire-induced forest damage is simulated at the stand level and is assessed based on the climatic conditions determining the degree of flammability of the available fuel at the forest floor, the structural characteristics of the forest and tree species specific characteristics. At each annual time step we calculated the

fuel load available to burn based on equation (1) (Schumacher and Bugmann 2006),

$$\text{Fuel load} = Kfc1 + (Kfc2 * \text{FWI} * \text{Bleaves}) + (Kfc3 * \text{FWI} * \text{Bwoody}) \quad (1)$$

where FWI included to account for fuel flammability induced by dry conditions. Bleaves and Bwoody are the pools of leaves and coarse woody litter available at the forest floor, respectively. The pools increase with litter input from biomass turnover, natural mortality and harvest residues, and decrease with species- and compartment-specific decomposition rates at every time-step, estimated with the soil model YASSO15 (Tuomi *et al* 2009, 2011). $Kfc1$, $Kfc2$ and $Kfc3$ are empirical parameters set to 0.8, 0.2 and 0.4, respectively (Schumacher and Bugmann 2006, Keane *et al* 2011, Seidl *et al* 2014). Fuel load is fully consumed during fire. We then calculated the fraction (%) of crown kill (ck) for each tree of the stand as a function of fuel load—which determines fire intensity—and DBH as proxy for tree size (equation (2), Seidl *et al* 2014),

$$ck = \min(\text{Fuel load} * (ck1 + ck2 * \text{DBHt}); 1) \quad (2)$$

where $ck1$ and $ck2$ are constant values (Schumacher and Bugmann 2006), while DBHt is the tree diameter with a threshold at $\text{DBH} = 40 \text{ cm}$. This threshold is set following the assumption that if the fire reaches the crowns of trees with $\text{DBH} = 40 \text{ cm}$, the wild-fire becomes a crown fire (Schumacher and Bugmann 2006, Fernández-Alonso *et al* 2013, Seidl *et al* 2014). The probability of tree mortality (P_{mort}) is calculated as function of ck and resistance to fire of the stem as a result of size- and species-specific bark thickness (equation (3)),

$$P_{\text{mort}} = \frac{1}{1 + e^{(-1.466 + 1.91 * (\text{DBH} * r\text{BT}) - 0.1775 * (\text{DBH} * r\text{BT}^2) - 0.000541 * ck^2)}} \quad (3)$$

where $r\text{BT}$ is the species-specific relative bark thickness, scaled with the dbh of the tree (Barrere *et al* 2023). P_{mort} is computed at the cohort level. Since a cohort represents trees of the same size and species modelled as one, P_{mort} is applied to damage a proportion of the cohort. This mimics the spatial heterogeneity of a fire within a stand, which is otherwise not captured in EFISCEN-Space, as trees within a stand are not spatially explicit in the model.

2.5. Forest simulations and analysis of fire impact

In EFISCEN-Space, the forest state was initialised using NFI data from the three study countries (table S1). Forest development in the model was run driven

by historical climate (2011–2018), and potential climate change effects on growth were not considered. The output of the model runs were analysed for the time period 2025–2098. The five disturbance scenario realisations for each GCM-RCP-country combination resulted in 135 scenario runs in EFISCEN-Space. We explored the distributions of BA and forest damage by dividing the century in three periods, representing its second (2025–2049), third (2050–2074) and last (2075–2098) quarter, respectively. Then we computed the historical mean BA (1994–2023, San-Miguel-Ayán *et al* 2023) and mean fire damage (1994–2023, Patacca *et al* 2023) for each country (table S3). We divided the modelled annual BA and

forest damage of each country by their respective historical average to derive relative changes. Finally, we assessed how a relative change in BA affected relative changes in forest damage for each country.

3. Results

The BA model showed a conditional R^2 of 0.64 (95% CI [0.618–0.662]), with posterior medians matching observed trends' magnitude and upper CIs capturing peak fire years (figure S1). The future BA scenario realisations—developed from the BA simulations (figure S2)—differed across countries and climate forcing scenarios (figure 2). Under RCP-2.6, countries maintained stable BA levels across the century. Under RCP-4.5, Spain and, to a lesser extent, Germany showed BA increases in the second half of the century. Occasional years with large extremes (i.e. outliers in figure 2) indicate exceptionally strong fire years (i.e. with BA outside the 75th percentile). Toward the end of the century, extremes became more frequent under RCP-8.5, with Spain showing a sharp BA increase, Germany a moderate increase, and Sweden more extremes with only a slight deviation from the other climate scenarios in the central tendency. Across GCMs, the MPI-ESM1-2-LR model simulated hotter conditions in southern Europe (Spain), leading to stronger VPD-driven fires, while the EC-EARTH model simulated drier conditions in northern and central Europe under more severe RCP scenarios (figure S2). Averaging GCM results before running simulations smoothed extreme fire peaks (figure S2).

Damage distributions differ from BA projections (figure 3). In Germany, damage decreases under RCP-2.6 and RCP-4.5 toward the end of the century, while under RCP-8.5 it peaks in the third quarter before declining in the last. Spain shows a similar pattern, but only under RCP-8.5 does damage rise exponentially, driven by the sharp increase in BA. In Sweden, damage declines under RCP-2.6 and RCP-4.5, but under RCP-8.5 it peaks in the second quarter, decreases, then peaks again late in the century, with a notably high number of extreme years.

Compared to the historical mean, BA increased throughout the century across all countries, climate scenarios, and GCMs (figure 4, x -axis). However, damage responses to BA varied between countries. We tested whether simulated damage trends follow a 1:1 line with BA (figure 4), with values above the 1:1 line indicating a disproportionate damage increase for a given increase in BA, while values below the 1:1 line indicate a disproportionately smaller increase in damage. In Germany under RCP-8.5, relative damage increased stronger than BA, with a tenfold BA increase resulting in a fifteenfold increase in forest damage, and a fortyfold BA increase yielding a fifty-fivefold increase in damage. In Spain, the same tenfold BA increase resulted in only a fivefold

increase in damage for the same climate scenario. In Sweden, damage responses remained close to the 1:1 line, i.e. with damage increasing proportionally to BA (figure 4). Milder scenarios showed similar but weaker patterns across countries.

4. Discussion

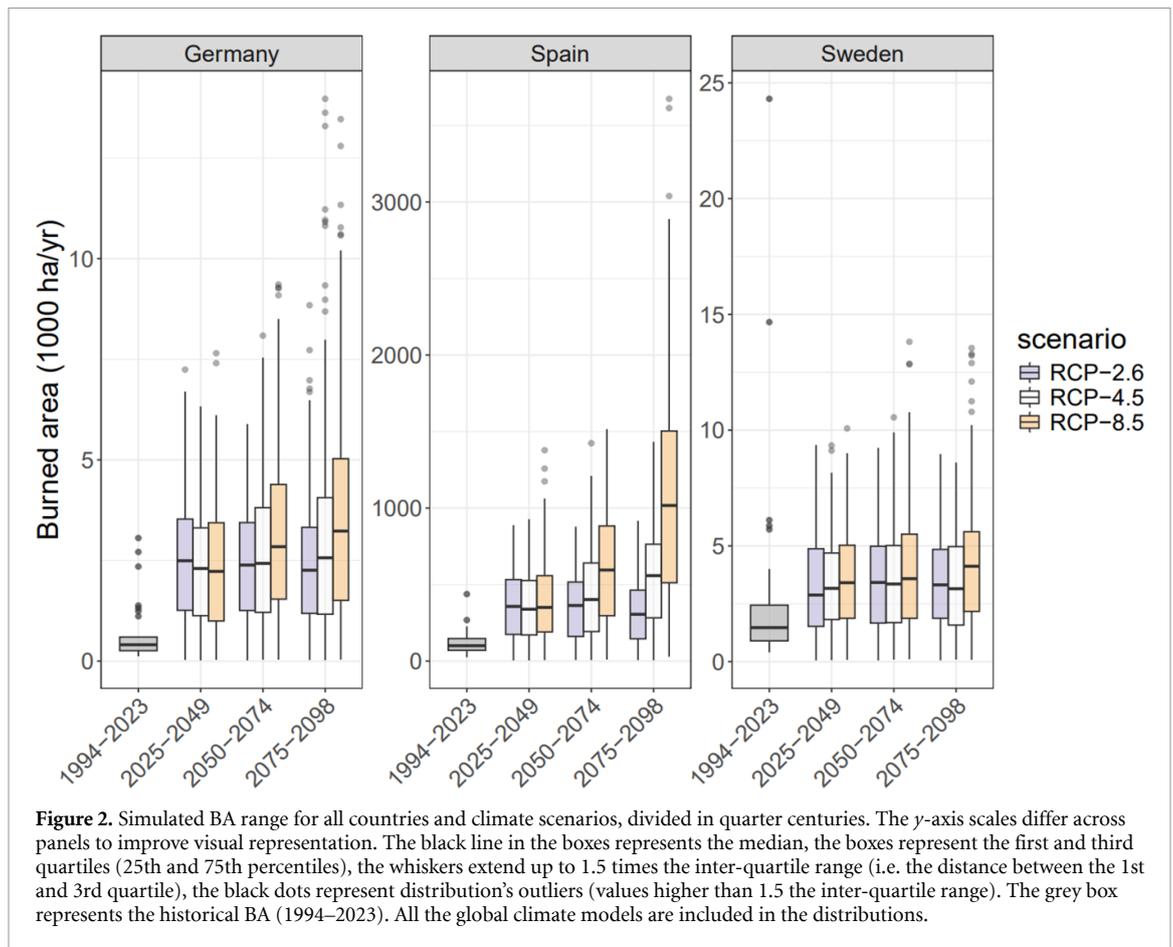
Despite observed (Jain *et al* 2024, Jones *et al* 2024) and expected (Grünig *et al* 2025) increases in climate-driven forest fires, their impacts on European forests remain uncertain. We projected BA over the century in Spain, Germany, and Sweden, representing Mediterranean, temperate, and boreal biomes. BA is projected to rise in all regions, with the strongest increase in the Mediterranean after 2075 under high-emission scenarios. In absolute terms, Mediterranean forests suffer the highest damage, driven by large BA. However, temperate forests show greater damage per unit BA increase, underscoring their particular vulnerability to emerging novel fire regimes and warranting fire management measures to become more important in the future.

4.1. Burned area increases over the century

In line with expectations, stronger climate forcings caused larger BA, independently of the region or GCM adopted (figure 2). In addition, our results show the BA increase is being driven by an increase in particularly extreme fire years especially in temperate and boreal regions (figure 2 outliers; Abatzoglou *et al* 2025), supporting recent warnings of fire regime shifts from many-small to fewer-large fires driving total BA (Pausas and Fernández-Muñoz 2012, Pausas and Keeley 2021, Turner and Seidl 2023). The magnitude of BA increase was much higher in Spain than in Germany or Sweden, as expected climate-change impacts are stronger in Mediterranean regions (Turco *et al* 2023) compared with boreal and temperate regions (Jain *et al* 2024, figure S2). Boreal regions, where increasing temperatures decrease fuel moisture and natural ignition is not limiting (Kelley *et al* 2019), have shown a recent staggering increase in BA (Jones *et al* 2024). However, this trend is mostly driven by fires in North America and Siberia, where remoteness limits prompt intervention (Jones *et al* 2024). In European boreal forests (e.g. Sweden), denser population and better accessibility result in more effective interventions. Nevertheless, results for Sweden suggest that climate alone might not fully represent the conditions needed for extreme fires (Pausas and Keeley 2021, see outlier in historical data in figure 2).

4.2. Fire-induced damage increase differs by region

Similar to BA, absolute fire damage is highest for Spain across all simulations (figure 3). However, relative to historical averages, temperate forests show the strongest increase in damage for a given relative increase in BA (figure 4), reflecting their higher

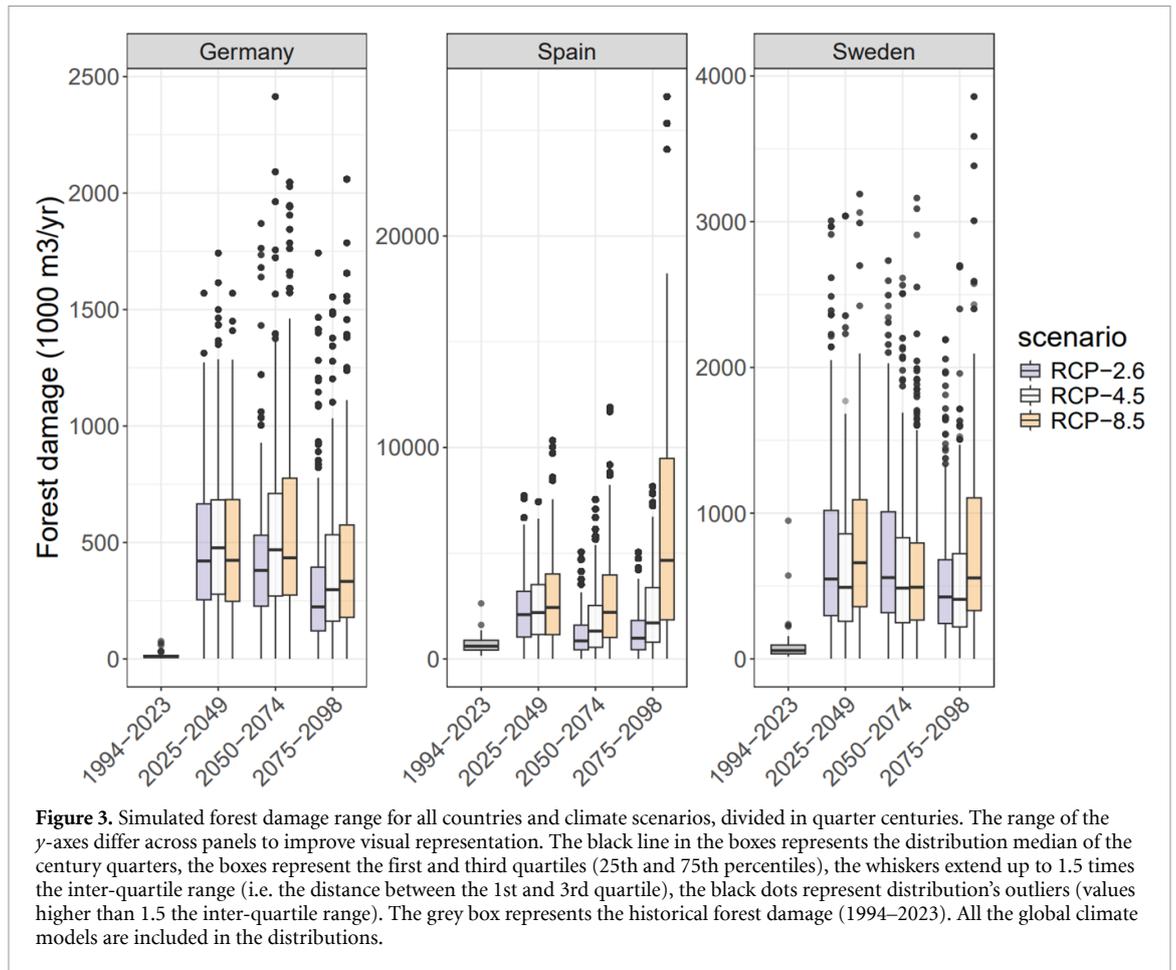


biomass stocks and vulnerability (figure S4). This supports our hypothesis that temperate forests are especially susceptible to BA increases. Temperate forests are highly productive due to favourable environmental conditions compared with boreal or Mediterranean systems (Pretzsch *et al* 2014, Schelhaas *et al* 2018b). Despite recent episodes of drought-induced mortality (Senf *et al* 2020), growth in many regions remains robust (Pretzsch *et al* 2023), likely supported by longer growing seasons as well as CO₂ and N fertilisation, while drought-induced impacts remain largely local (Peñuelas *et al* 2017). Higher biomass production increases fuel loads, which, combined with warmer and drier conditions in the future, elevates flammability and fire impacts (equation (1), figure S5). Additionally, temperate tree species largely lack co-evolutionary traits of fire adaptation (Keeley and Pausas 2022), such as thick bark (Keeley *et al* 2011), or have large, short-lived leaves (Peguero-Pina *et al* 2020), which increase fuel load.

In Mediterranean forests, an increase in BA resulted in a disproportionately lower increase in forest damage (figure 4), consistent with our hypothesis. In hot and dry Mediterranean systems tree growth is slow (Martinez Del Castillo *et al* 2022), limiting fuel build-up. At the same time, species have co-evolved with fire, developing effective traits to resist, avoid,

or embrace fire. However, low moisture levels slow organic matter decomposition (Neumann *et al* 2022, Lin *et al* 2024), allowing fuel accumulation even with lower growth-rates. When fuel is not limiting and fire weather is severe, species traits might be insufficient to prevent mortality (figure S6). Nonetheless, because of lower levels of growing-stock, fires lead to lower relative damage than in temperate or boreal forests (figures 4 and S4).

In Sweden, BA increase resulted in proportional forest damage increase (figure 4). European boreal forests were long perceived as undisturbed before the beginning of industrial forest exploitation in the 19th century (Östlund *et al* 1997). However, charcoal and fire scars (Zackrisson 1977) showed that historically fires played an important role for forest dynamics (Drobyshev *et al* 2015). Traditional land uses (e.g. reindeer herding, Cogos *et al* 2019), followed by industrial-scale tree harvesting (Östlund *et al* 1997) have altered fire regimes by reducing fuel loads and modifying forest structures (Zackrisson 1977, Östlund *et al* 1997). Due to its co-evolution with fire, some boreal trees have fire-resistant traits, which can reduce damage at low fire intensities. At the same time, the intense management of boreal forests (Turubanova *et al* 2023, Suvanto *et al* 2025) maintains the growing-stock and fuel load low, containing damage.



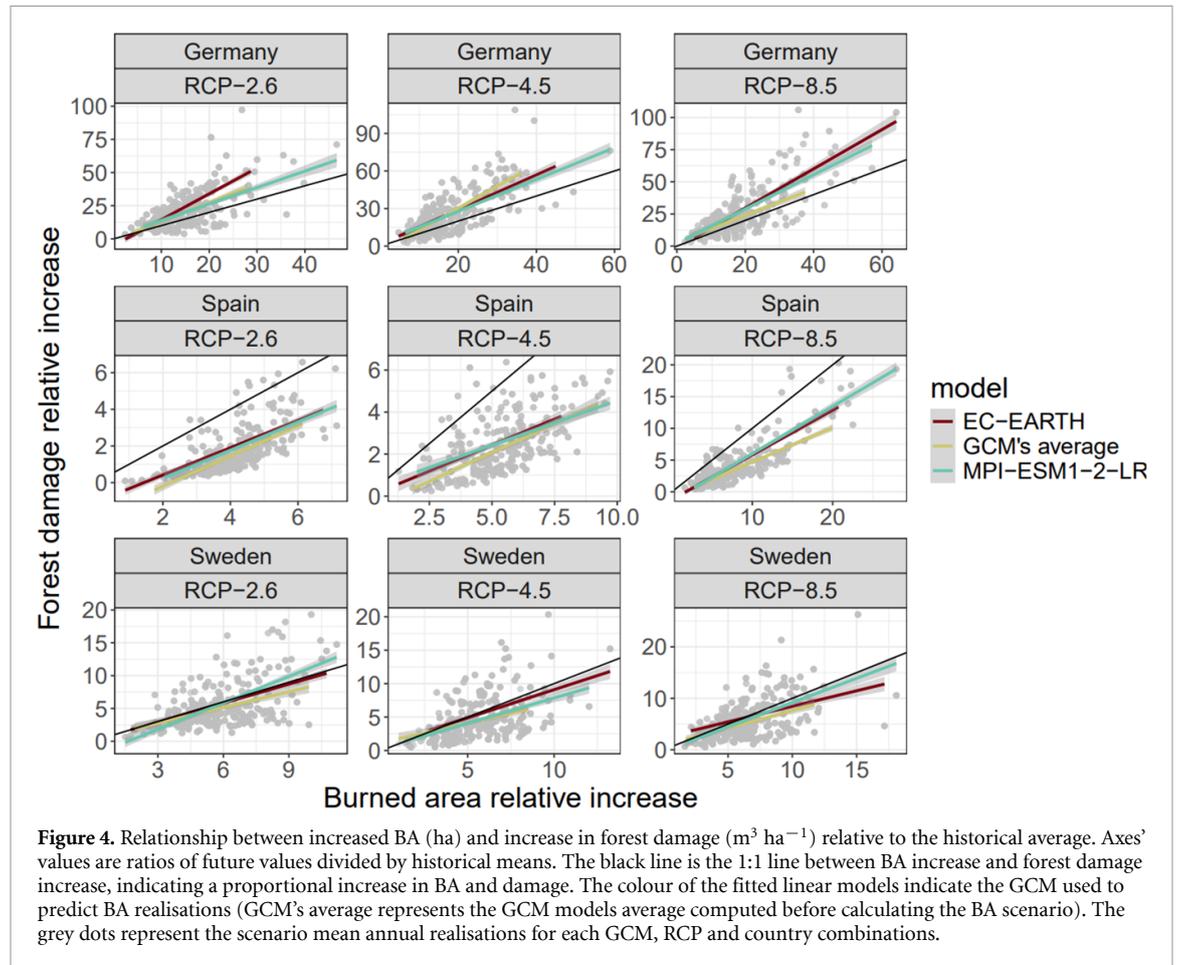
Some scenarios resulted in decreasing damage as BA increased along the century (figure 3). This emerging pattern is explained by GCM projections of rising FWI concentrated in specific regions (e.g. SW-Germany, S-Sweden, figure S7), leading to fuel limitations. We show a consistent shift toward lower growing-stock in burned plots over time (figure S8). Recurrent fires in regions with increasing FWI alter stand demography and fuel loads: growing-stocks decline, forests become younger and more open, consequently suffering less damage later in the century.

4.3. Critical evaluation of assumptions

In our modelling, we deliberately excluded direct climate effects on vegetation growth to isolate fire impacts from climate-driven vegetation dynamics. However, such feedbacks are likely to alter damage patterns across biomes (Grünig *et al* 2025). In temperate and boreal forests, longer growing seasons may increase biomass production (Piao *et al* 2007, Park *et al* 2016), promoting fuel accumulation. Combined with drier conditions (figure S7), this would amplify fire-induced damage, making our estimates conservative, especially under moderate climate scenarios, where climate-driven growth responses may remain positive (Peñuelas *et al* 2017). In Mediterranean

forests, climate-driven drying could reduce biomass production and fuel loads, potentially lowering damage relative to our projections. Yet historical evidence suggests that drought-adaptive traits help maintain productivity also under dry conditions (García-Valdés *et al* 2021), but it remains unclear whether these mechanisms persist under strong future climate forcing.

Our results show that averaging GCM data before predicting BA (i.e. GCMs average, figure 4) reduces peak years and individual fire sizes (figure S2), leading to an underestimation of BA. This aligns with Jensen's inequality (Jensen 1906), for which a system's response to average conditions differs from its average response to variable conditions (Denny 2017). This mechanism might explain why GCMs fall short in predicting unprecedented large extremes, especially where severe fire weather is not common (i.e. Sweden, see historical outliers in figure 2). Moreover, we did not directly take into account fuel management, which could dampen or amplify fire vegetation damage (Hsu *et al* 2025). However, because our BA projection models were trained on spatially-explicit historical observations, factors determining fire behaviour like regional fuel management strategies, fire suppression, wildland–urban interface, and ignition sources were indirectly considered in BA estimates.



The implications wildfires can have on other ecosystem components and processes such as soils nutrients (Caon *et al* 2014), water retention capacity and erosion control (Ice *et al* 2004), below-ground carbon sink (Jones *et al* 2019, Walker *et al* 2019, Bowring *et al* 2022), damage to infrastructure and human well-being (Seydi *et al* 2025) as well as economic damages (Mohr *et al* 2025) were not included in the analyses here.

4.4. Conclusion and implications

Climate-driven increases in BA are projected to affect forests across Europe. Mediterranean forests have lower growing-stock per hectare, while temperate and, to a lesser extent, boreal forests hold higher biomass, making them more vulnerable to fire damage. Although projected fire-induced losses represent only a small share of national biomass, local impacts on ecosystem services, forest-dependent livelihoods, and regional carbon sinks may be significant (Jones *et al* 2019, Lecina-Diaz *et al* 2024). Fire damage is mainly driven by fire weather and fuel availability. Regions facing stronger increases in fire weather (figure S7) with high-biomass forests are at greatest risk. This highlights the need to integrate fire-risk mitigation into forest planning, particularly in areas projected

to become drier. Short-term strategies include prescribed burning (Fernandes *et al* 2022), fuel breaks in landscape planning (Ortega *et al* 2024), agro-pastoral land management (Moreno *et al* 2023), and knowledge transfer across regions. In the longer term, selecting fire-adapted species may help reduce damage from low-intensity fires. However, such measures can conflict with other objectives: for example, increasing deadwood to foster biodiversity (Seibold *et al* 2015) and maintaining biogeochemical cycles (Harmon 2021) may increase fuel loads with negative consequences for fire risk. Another example of such conflicts in decision making could be salvage logging after disturbance. Because forest management involves balancing multiple objectives, we argue that fire-risk mitigation should be mainstreamed into planning. Decision support tools like fire weather projections or fuel management tools (e.g. Russo *et al* 2016) are increasingly accessible to decision-makers and should be used when designing forest management plans.

Data availability statement

The data concerning historical BA trends, BA scenarios and country aggregated damages to reproduce

the main findings of the research are available at <https://github.com/MarcoPatacca/Climate-driven-increases-in-wildfire-projected-to-affect-European-forest-types-differently-> (Patacca *et al* 2026). The procedures applied for the BA modelling are publicly available at <https://zenodo.org/records/7386862>. The NFI data used for initialising the EFISCEN-Space model are publicly available for Germany (at <https://bwi.info/>) and Spain (at www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/). The Swedish NFI data are not publicly available and are accessible through formal personal agreements with official country's NFI representative office. The EFISCEN-Space model is developed and licensed by Wageningen Environmental Research (WEnR) since 2013 and can become available to interested users through formal license agreement with the Licensor. The code produced to analyse the model outcomes and produce the study figures is available upon reasonable request to the authors.

Supplementary materials available at <http://doi.org/10.1088/1748-9326/ae4115/data1>.

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Conflict of interest

The authors declare no conflict of interest.

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