Supplementary File S1

Spatial analysis and national descriptive comparison

© EuroGeographics for the administrative boundaries

Analytical scope and data

This supplement documents the analysis underlying Figure 2 and Supplementary Table S1. The spatial unit is the NUTS-3 region. The fixed domain comprises 322 NUTS 2024 regions: all regions in Portugal, Spain, Italy, Slovenia, Croatia and Greece, and the French NUTS-1 areas Nouvelle-Aquitaine (FRI), Occitanie (FRJ), Auvergne-Rhône-Alpes (FRK), Provence-Alpes-Côte d'Azur (FRL) and Corse (FRM).

The French boundary is an explicit administrative definition for this analysis, not an official definition of southern France. Slovenia and Croatia extend the descriptive comparison into the northern Adriatic. These choices do not imply that every included region is rural, low density or climatically Mediterranean.

EFFIS MODIS/Sentinel-2 mapped perimeters were retrieved through the official WFS modis.ba.poly service for calendar years 2016–2023. Each annual query was filtered by FIREDATE and country. Greece was retrieved using the source's EL country code. All 21,495 downloaded records matched the server's resultType=hits counts; unique event identifiers and year membership were checked. The source extracts include all of France; the spatial intersection restricts the analysis to the selected French regions.

Eurostat demo_r_pjanaggr3 supplied 2023 population for both sexes, ages TOTAL and Y_GE65, in persons. Dataset demo_r_d3dens supplied population density for 2023 in persons/km². Source values and flags were retained. Exact NUTS 2024 identifiers were used without demographic interpolation or recoding. GISCO regional polygons were obtained at 1:1 million scale in EPSG 3035. A coarser GISCO country layer provides cartographic context only.

Spatial indicators and coverage

Fire perimeters were transformed from longitude/latitude coordinates to ETRS89-LAEA Europe (EPSG 3035). One invalid fire geometry was repaired. Each perimeter was intersected with candidate NUTS-3 regions; the resulting pieces were united within each region-year. This is set-equivalent to unioning each year before regional intersection, and counts a place once within a year but again if it burns in a different year. Annual footprint was checked against regional polygon area.

The mean annual mapped burnt area equals the sum of eight annual union areas divided by eight. Dividing that mean by regional polygon area produces ha/km²/year. A zero denotes no mapped footprint in the complete returned archive for that region-year; it does not establish that no fire occurred. The Azores indicator was withheld because

coverage of that archipelago could not be established. Supplementary Table S1 explicitly records this coverage exclusion.

The ageing indicator equals 100 times the population aged 65 and over divided by total population. Density uses the published Eurostat value, rather than dividing the January population by GISCO cartographic area. These denominators and reference concepts need not be identical. All demographic observations represent 2023, not the full historical fire period.

Classification and numerical results

All thresholds were computed on the same pool of 310 regions with complete indicators, using equal weight per region and NumPy's linear quantile method, equivalent to R quantile type 7. Low includes values at or below the lower cut-point; Medium includes values above the lower and at or below the upper cut-point; High includes values above the upper cut-point. Ties are not split, so category counts need not be exactly equal. Calculations use full precision; the numerical thresholds are reported below.

Tertiles were selected as a transparent relative description of the regional distributions. They are not thresholds validated against clinical, social or economic outcomes. Equal weighting counts co-occurring conditions without asserting equivalent causal effects. No sensitivity analysis establishing robustness to alternative domains, cut-points or weights is claimed.

wildfire_exposure_ha_km2_year: lower cut-point 0.0140743260301929; upper cut-point 0.166416537846289.

population_65plus_pct: lower cut-point 23.0195125884416; upper cut-point 25.6280692685448.

population_density_2023: lower cut-point 58.3; upper cut-point 160.7.

One point is assigned for High wildfire exposure, one for High population ageing and one for Low density. The resulting distribution is Class 0, 100 regions; Class 1, 129; Class 2, 62; and Class 3, 19. Twelve regions remain unclassified. Classes describe the count of conditions, not validated risk levels. A relative density tertile is not equivalent to a DEGURBA or rural classification.

Density was unavailable in the selected 2023 extract for HR050, HR061, HR062, HR063, HR064, HR065, ITG2D, ITG2E, ITG2F, ITG2G and ITG2H. These eleven regions and PT200 (Azores, unverified fire-archive coverage) are marked No data. No values were imputed. Incomplete regions do not contribute to any threshold and receive no score.

Limitations

EFFIS maps burnt scars and does not consistently distinguish wildfires from prescribed or environmental burns. Smaller fires became more detectable with Sentinel-2 support from 2018, affecting comparability within the study period. No additional fire-size filter was imposed. The indicator is a mapped-footprint proxy, not complete wildfire incidence, household exposure or a measure of psychological harm. Generalised GISCO boundaries approximate administrative area. Scores depend on the domain, boundaries, complete-case pool and relative thresholds; no causal inference is warranted.

Computational environment

The analysis used Python 3.12.14, NumPy 2.3.5, pandas 2.2.3, Shapely 2.1.2 and pyproj 3.8.0. Supplementary Table S1 reports the regional identifiers, source values and flags, derived indicators, coverage and missing-data status, tertile assignments and final overlap classifications. Blank indicator or classification fields denote unavailable or withheld values, not zero. Source flag fields are retained as supplied by Eurostat.

Official sources

https://maps.effis.emergency.copernicus.eu/effis

https://forest-fire.emergency.copernicus.eu/about-effis/technical-background/rapid-damage-assessment

https://ec.europa.eu/eurostat/databrowser/view/demo_r_pjanaggr3/default/table

https://ec.europa.eu/eurostat/databrowser/view/demo_r_d3dens/default/table

https://gisco-services.ec.europa.eu/distribution/v2/nuts/

National comparison in Figure 1

Figure 1 preserves the national comparison for Portugal, Spain, France, Italy and Greece in 2023. The share aged 65 and over was calculated from the national geo codes in the frozen Eurostat demo_r_pjanaggr3 extracts, using both sexes, Y_GE65 divided by TOTAL. The values rounded to one decimal place are Portugal 23.9%, Spain 20.1%, France 21.1%, Italy 24.0% and Greece 23.0%. These are country aggregates, not aggregates restricted to the regional mapping domain.

Burnt areas are nationally reported values in San-Miguel-Ayanz et al. (2024), Table 1, printed page 9 (PDF page 14): Portugal 34,510 ha, Spain 89,068 ha, France 5,361 ha, Italy 88,806 ha and Greece 136,499 ha. The report explicitly identifies the French value as forest fires only. National reporting definitions and geographical coverage may differ;

absolute area also depends on country size and the chosen year. These data are not a harmonised risk ranking and no correlation or age-effect test is conducted.

The national report series in Figure 1 and EFFIS mapped perimeters for 2016–2023 in Figure 2 are distinct products with different periods, measurement definitions and spatial units. Figure 1 provides national context; Figure 2 describes within-region mapped-footprint intensity and relative overlap. The two analyses are not pooled.

Code and accompanying materials

Supplementary File S3 supplies frozen geographical source data, provenance records, numerical outputs, computational requirements and Python scripts. Supplementary Table S4 describes the narrative search framework and relevance criteria. Supplementary Table S5 summarises primary-study evidence and contextual sources.

San-Miguel-Ayanz, J., Durrant, T., Boca, R., Maianti, P., Libertà, G., Oom, J. F., Branco, A., de Rigo, D., Suarez-Moreno, M., Ferrari, D., Roglia, E., Scionti, N., Broglia, M., Onida, M., Tistan, A., & Löffler, P. (2024). Forest fires in Europe, Middle East and North Africa 2023. Publications Office of the European Union. https://doi.org/10.2760/8027062