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Supplementary Material

Future expansion, seasonal lengthening and intensification of fire activity under climate change in southeastern France

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Supplementary material

Lengthening, extension and intensification of future fire activities in South-Eastern France

Supporting information

Table S1. EURO-CORDEX experiments (i.e. GCM-RCM couples) used for FWI projections in RCP 4.5 and 8.5. Each experiment includes one historical and two scenario (RCP4.5 and RCP8.5) runs; spanning the periods 1970-2005 and 2006-2099 respectively. Although they provide the required outputs, models in red have not been used for multi-model computation, because of know issues in the forcings. (http://www.drias-climat.fr/document/Doc-Limitation-Simulations-EUROCORDEX-2014_v20201130.pdf)

Forcing GCM	Run	RCM	Institution
CNRM-CM5	r1i1p1	RCA 4	Centre National de Recherches Météorologiques (CNRM) / Swedish Meteorological and Hydrological Institute (SMHI)
CSIRO-Mk3-6-0	r1i1p1	RCA 4	CSIRO Marine and Atmospheric Research / Swedish Meteorological and Hydrological Institute (SMHI)
HadGEM2-ES-01	r1i1p1	RACMO 2.2	Met Office / Royal Netherlands Meteorological Institute (KNMI)
HadGEM2-ES-01	r1i1p1	RCA 4	Met Office / Swedish Meteorological and Hydrological Institute (SMHI)
EC-EARTH	r3i1p1	HIRHAM 5	Irish Centre For High-End Computing (ICHEC) / Danish Meteorological Institute (DMI)
EC-EARTH	r1i1p1	RACMO 2.2	Irish Centre For High-End Computing (ICHEC) / Royal Netherlands Meteorological Institute (KNMI)
EC-EARTH	r12i1p1	RCA 4	Irish Centre For High-End Computing (ICHEC) / Swedish Meteorological and Hydrological Institute (SMHI)
IPSL-CM5A-MR	r1i1p1	RCA 4	Irish Centre For High-End Computing (ICHEC) / Swedish Meteorological and Institut Pierre Simon Laplace (IPSL) / Hydrological Institute (SMHI)
IPSL-CM5A-MR	r1i1p1	WRF331F	Institut Pierre Simon Laplace (IPSL) / IPSL INERIS
MIROC5	r1i1p1	RCA 4	Japan Agency for Marine-Earth Science and Technology / Swedish Meteorological and Hydrological Institute (SMHI)
MPI-ESM-LR	r1i1p1	RCA 4	Max-Planck-Institut für Meteorologie / Swedish Meteorological and Hydrological Institute (SMHI)
MPI-ESM-LR	r1i1p1	REMO2009	Max-Planck-Institut für Meteorologie / Climate Service Center (CSC)
MPI-ESM-LR	r2i1p1	REMO2009	Max-Planck-Institut für Meteorologie / Climate Service Center (CSC)
CanESM2	r1i1p1	RCA4	Canadian Centre for Climate Modelling / Swedish Meteorological and Hydrological Institute (SMHI)
NorESM1-M	r1i1p1	RCA4	Norvegian Meteorological Institute / Swedish Meteorological and Hydrological Institute (SMHI)
GFDL-ESM2M	r1i1p1	RCA4	Geophysical Fluid Dynamics Laboratory (GFDL) / Swedish Meteorological and Hydrological Institute (SMHI)

Table S2. Dates for which degrees of global warming are reached from each GCM. Corresponding data was obtained from the IPCC-WGI Atlas repository (https://github.com/IPCC-WG1/Atlas/blob/main/warming-levels/CMIP5_Atlas_WarmingLevels.csv)

RCP		**4.5**				**8.5**			
Warming levels in °C		**1.5**	**2**	**3**	**4**	**1 .5**	**2**	**3**	**4**
CNRM-CM5	r1i1p1	2036	2057	NA	NA	2030	2045	2067	2087
CSIRO-Mk3-6-0	r1i1p1	2035	2048	NA	NA	2034	2044	2065	2082
HadGEM2-ES-01	r1i1p1	2028	2043	2078	NA	2023	2035	2054	2071
HadGEM2-ES-01	r1i1p1	2028	2043	2078	NA	2023	2035	2054	2071
ICHEC-EC-EARTH	r3i1p1	2022	2044	NA	NA	2020	2038	2061	2081
ICHEC-EC-EARTH	r1i1p1	Not available							
ICHEC-EC-EARTH	r12i1p1	2022	2044	NA	NA	2018	2034	2060	2082
IPSL-CM5A-MR	r1i1p1	2016	2033	2077	NA	2015	2030	2050	2066
IPSL-CM5A-MR	r1i1p1	2016	2033	2077	NA	2015	2030	2050	2066
MIROC5	r1i1p1	2039	2071	NA	NA	2033	2048	2072	NA
MPI-ESM-LR	r1i1p1	2022	2044	NA	NA	2017	2037	2061	2081
MPI-ESM-LR	r1i1p1	2022	2044	NA	NA	2017	2037	2061	2081
MPI-ESM-LR	r2i1p1	Not available							
CanESM2	r1i1p1	2017	2031	2075	NA	2013	2026	2049	2068
NorESM1-M	r1i1p1	2039	2072	NA	NA	2032	2048	2072	NA
GFDL-ESM2M	r1i1p1	2046	NA	NA	NA	2036	2051	2082	NA

Table S3. Improvements in Deviance Information Criterion (DIC) with the inclusion of "Besag" spatial effect associated with NUT3 levels.

Size model component	Null (Pimont et al. 2021)	FWI+FA (Pimont et al. 2021)	FWI+FA+NUTS3 (This study)
Exceedance probability $P(S \geq 10 \mid S \geq 1)$	5519	5230	5158
Exceedance probability $P(S \geq 100 \mid S \geq 1)$	1945	1753	1731
Exceedance probability $P(S \geq 100 \mid S \geq 1)$	412	390	386
Exponential distribution between 1 and 10ha	11673	11486	11437
Exponential distribution between 10 and 100ha	2341	2331	2330
Exponential distribution between 100 and 1000ha	505	504	503

Table S4. Observed fire activity metrics for different periods

Metric	2004-2019[1]	2001-2019[2]	1993-2002[3]	1993-2003
N1ha	206	281	310	330
N10ha	8.43	13.8	14.6	17.9
BA	6030	10900	9870	14300

[1] The version of Firelihood used in this study is representative of stationary fire weather relationships corresponding to this period (selected to plot observations in Fig. 2)
[2] True observations corresponding to 2001-2020 (including shifts in fire weather relationships before 2004 and the catastrophic 2003 year)
[3] Observations corresponding to 1993-2002, which exhibited much higher fire activities than (2004-2019) for a same fire weather level according to Pimont et al. (2021) and Castel-Clavera et al. (2022)

Table S5. Increases in fire activity metrics associated with the different global warming levels

Metric	2001-2020	+1.5°C	+2°C	+3°C	+4°C
N1ha	183	205 (+11.6%)	227 (+23.6%)	278 (+51.4%)	339 (+85.1%)
N10ha	29.8	35.4 (+18.7%)	40.7 (+36.4%)	54.0 (+88.8%)	72.2 (+142%)
N100ha	6.42	7.97 (+24.2%)	9.35 (+45.6%)	12.9 (+100%)	18.1 (+181%)
N1000ha	0.994	1.19 (+20.1%)	1.39 (+39.7%)	1.86 (+87.3%)	2.52 (+154%)
BA	5010	6060 (+21.1%)	7050 (+40.7%)	9490 (+89.4%)	12900 (+158%)
FWI	10.2	11.0 (+7.02%)	12.0 (+16.7%)	14.0 (+36.2%)	16.1 (+57.1%)
DSR	2.96	3.28 (+10.6%)	3.70 (+24.9%)	4.58 (+54.4%)	5.59 (+88.7%)

Table S6. Increases in fire activity metrics associated for RCP 8.5

Metric	2001-2020	2020	2030	2040	2050	2060	2070	280	2090
N1ha	183	200 (+9.01%)	212 (+15.7%)	230 (+25.6%)	254 (+38.3%)	278 (+51.5%)	308 (+67.8%)	338 (+84%)	373 (+103%)
N10ha	29.8	34.3 (+15%)	37.1 (+24.2%)	41.5 (+38.9%)	47.9 (+60.5%)	54.4 (+82.3%)	62.9 (+111%)	71.8 (+141%)	82.7 (+177%)
N100ha	6.42	7.69 (+19.8%)	8.39 (+30.6%)	9.51 (+48.1%)	11.3 (+75.5%)	13 (+103%)	15.4 (+140%)	18 (+180%)	21.2 (+229%)
N1000ha	0.994	0.994 (+16.6%)	1.16 (+26%)	1.25 (+41.8%)	1.41 (+65.7%)	1.65 (+88.5%)	1.87 (+120%)	2.19 (+153%)	2.92 (+194%)
BA	5010	5870 (+17.1%)	6360 (+27.0%)	7160 (+43.1%)	8370 (+67.2%)	9570 (+91.1%)	11200 (+123%)	12900 (+157%)	15000 (+200%)
FWI	10.2	10.7 (+4.82%)	11.4 (+11.1%)	12.1 (+18.4%)	13 (+26.5%)	13.9 (+35.5%)	14.9 (+45.5%)	16 (+56%)	16.9 (+64.9%)
DSR	2.96	2.96 (+7.3%)	3.18 (+16.5%)	3.45 (+27.5%)	4.15 (+40.1%)	4.57 (+54.0%)	5.04 (+70.0%)	5.54 (+87.0%)	5.98 (+102%)

Table S7. Increases in fire activity metrics associated for RCP 4.5

Metric	2001-2020	2020	2030	2040	2050	2060	2070	280	2090
N1ha	185	199 (+7.67%)	218 (+18.1%)	238 (+28.8%)	245 (+32.5%)	243 (+31.9%)	252 (+36.3%)	254 (+37.8%)	253 (+37%)
N10ha	30.0	33.4 (+11.3%)	38.4 (+28.2%)	43.3 (+44.5%)	45.1 (+50.4%)	44.8 (+49.4%)	46.8 (+56%)	47.7 (+59%)	47.3 (+57.9%)
N100ha	6.48	7.37 (+13.6%)	8.73 (+34.6%)	9.99 (+54.0%)	10.4 (+61.1%)	10.4 (+59.9%)	10.9 (+68.6%)	12.2 (+72.6%)	11.1 (+70.8%)
N1000ha	1.0	1.12 (+11.5%)	1.31 (+30.4%)	1.47 (+46.7%)	1.52 (+51.9%)	1.52 (+52%)	1.61 (+60.2%)	1.63 (+62.6%)	1.61 (+61%)
BA	5050	5660 (+12.2%)	6620 (+31.2%)	7490 (+48.3%)	7770 (+54.0%)	7750 (+53.6%)	8160 (+61.6%)	8300 (+64.5%)	8230 (+63%)
FWI	10.4	10.8 (+4.51%)	11.4 (+10.3%)	12.0 (+15.8%)	12.4 (+19.4%)	12.6 (+21.7%)	12.8 (+23.3%)	12.9 (+24%)	12.9 (+24.6%)
DSR	3.0	3.2 (+6.6%)	3.45 (+16.1%)	3.70 (+23.4%)	3.86 (+28.6%)	3.95 (+31.7%)	4.01 (+33.8%)	4.05 (+34.9%)	4.08 (+35.9%)

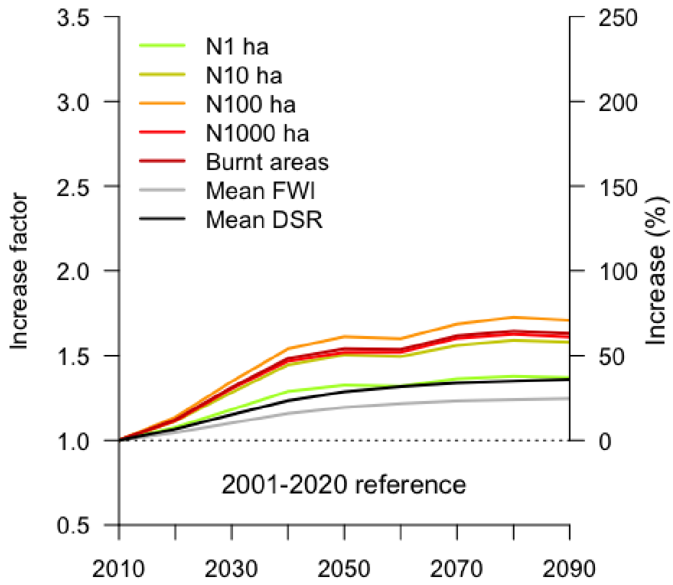

Fig. S1. Same as Fig. 3 for RCP 4.5

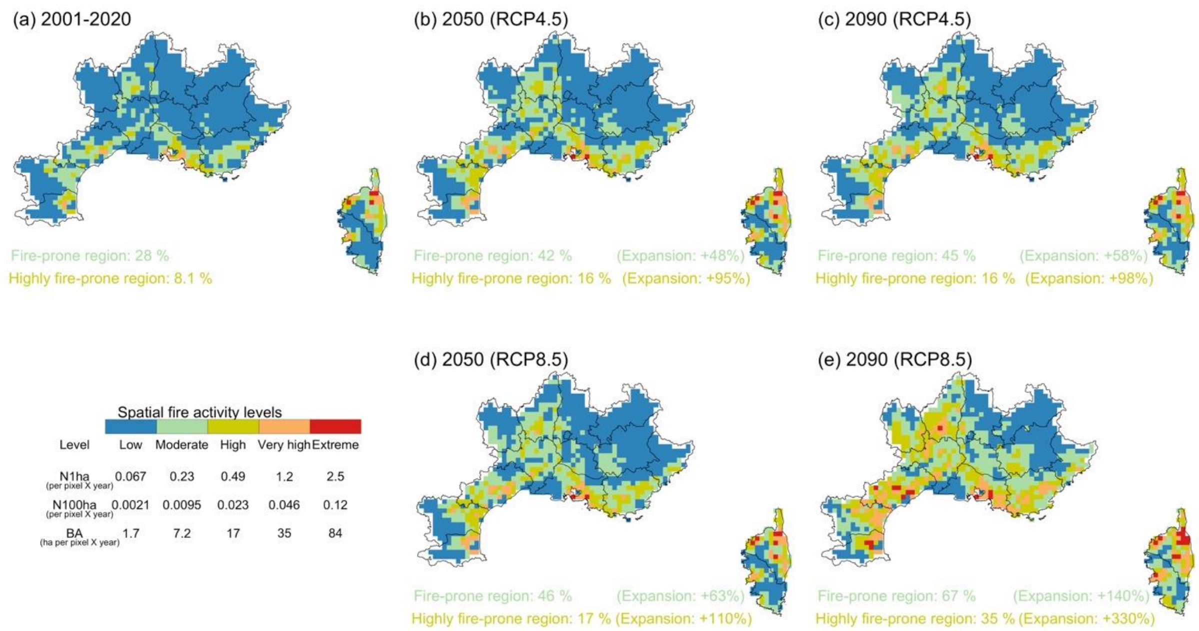

Figure S2. Same as Fig. 4 for mid and long term horizons and RCP.

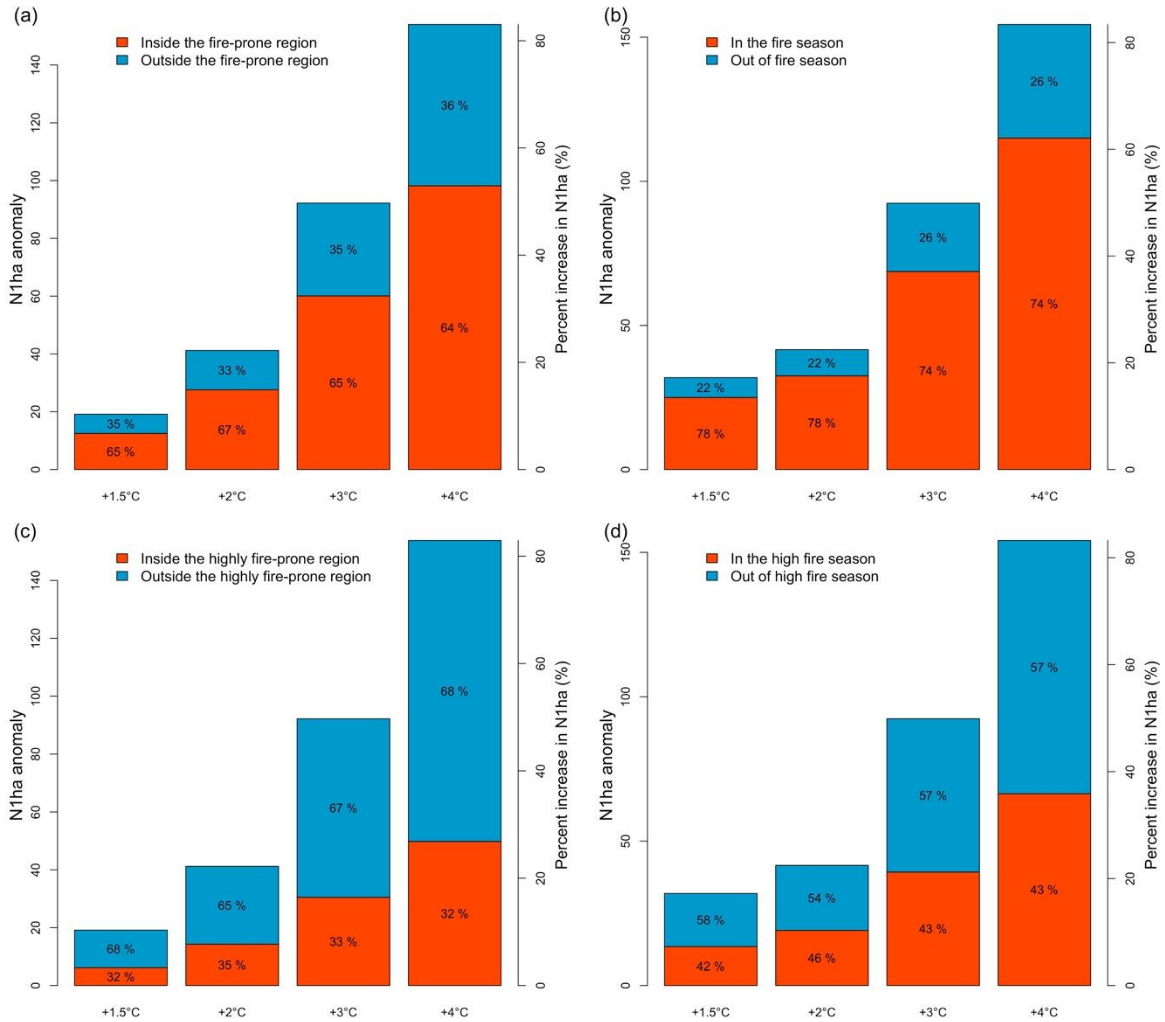

Figure S3. Same as Fig. 7, for N1ha, instead of N100ha.

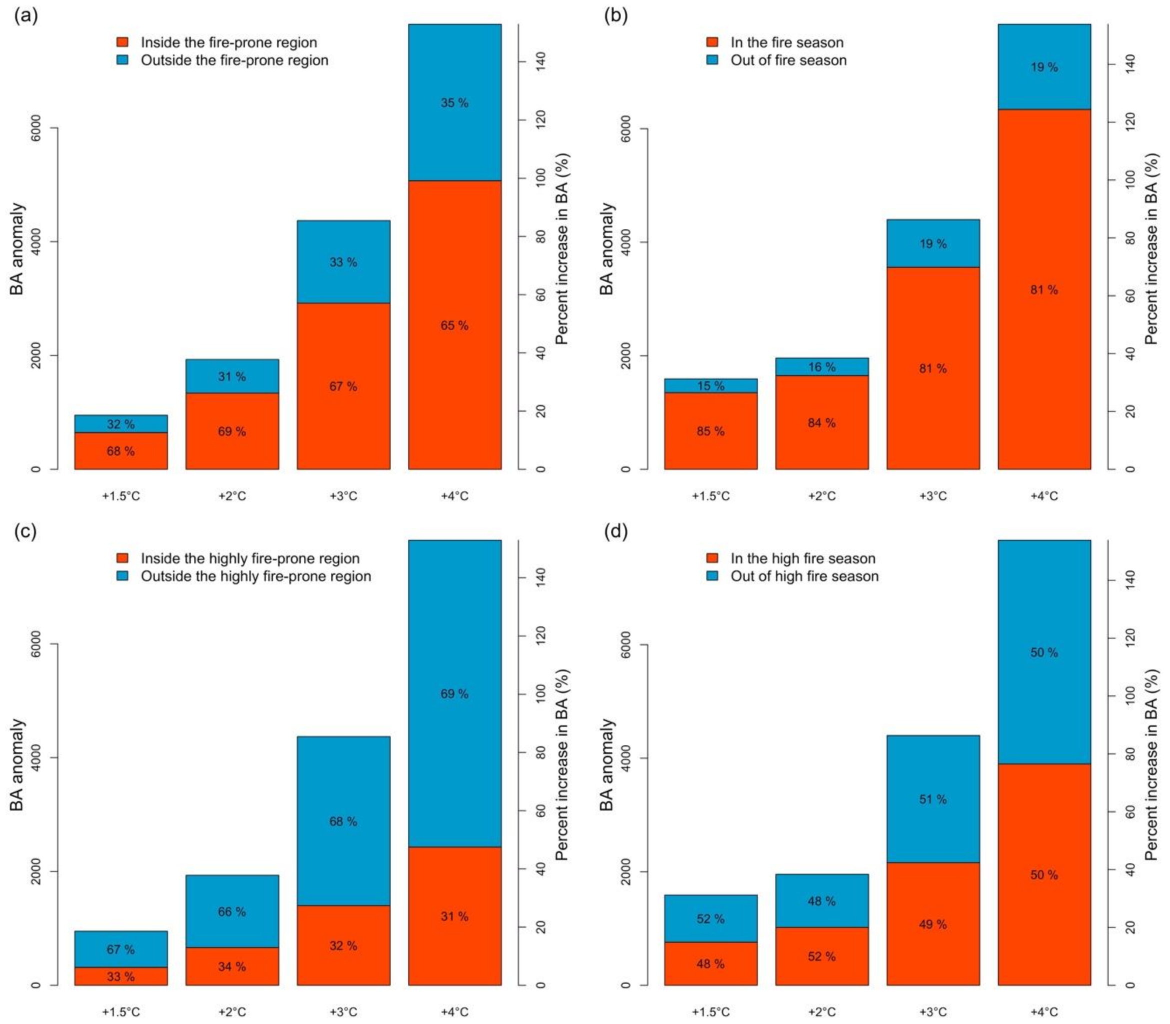

Figure S4. Same as Fig. 7, for burned area (BA), instead of N100ha.

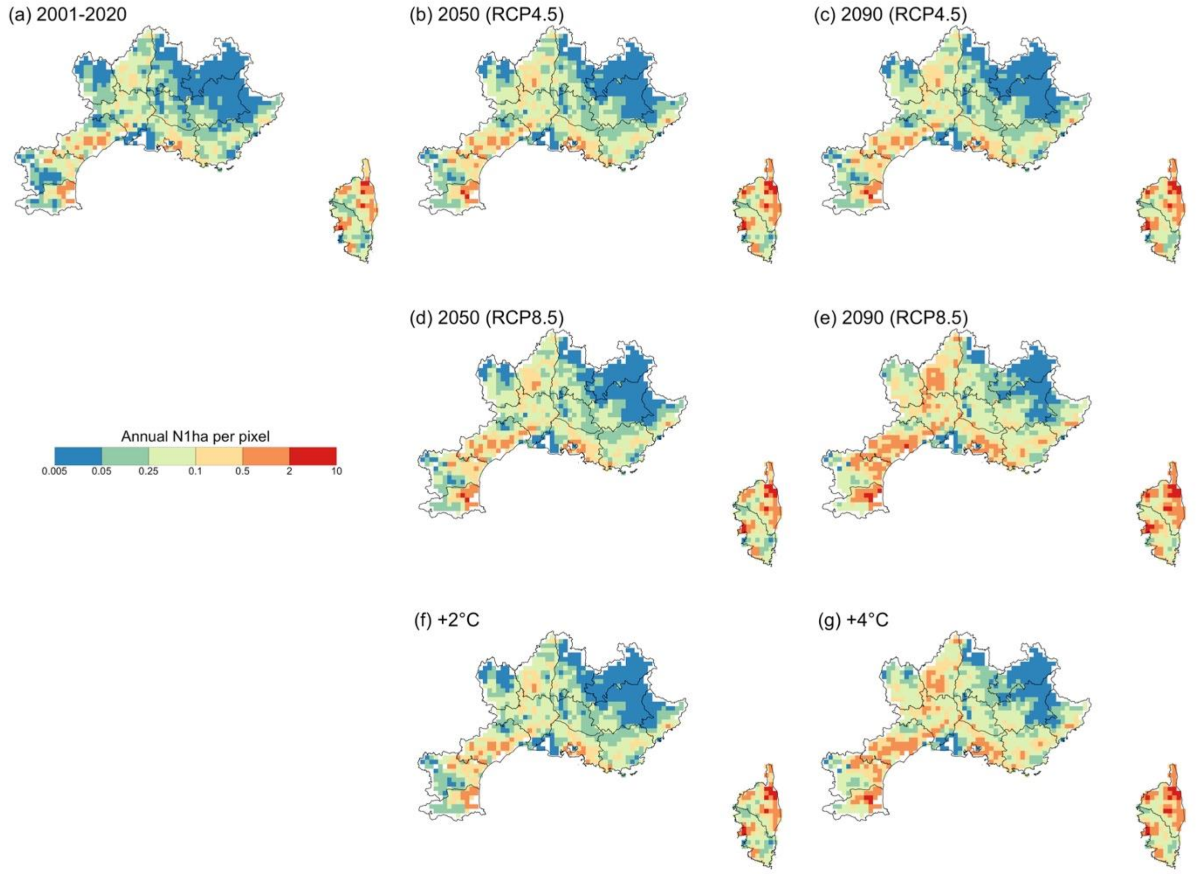

Figure S5. Spatial distribution of projected annual escaped fires (N1ha) for (a) the historical reference; (b) and (c) mid and long-term periods under RCP 4.5; (d) and (e) mid and long periods under RCP 8.5; and (f) and (g) +2°C and +4°C of global warming.

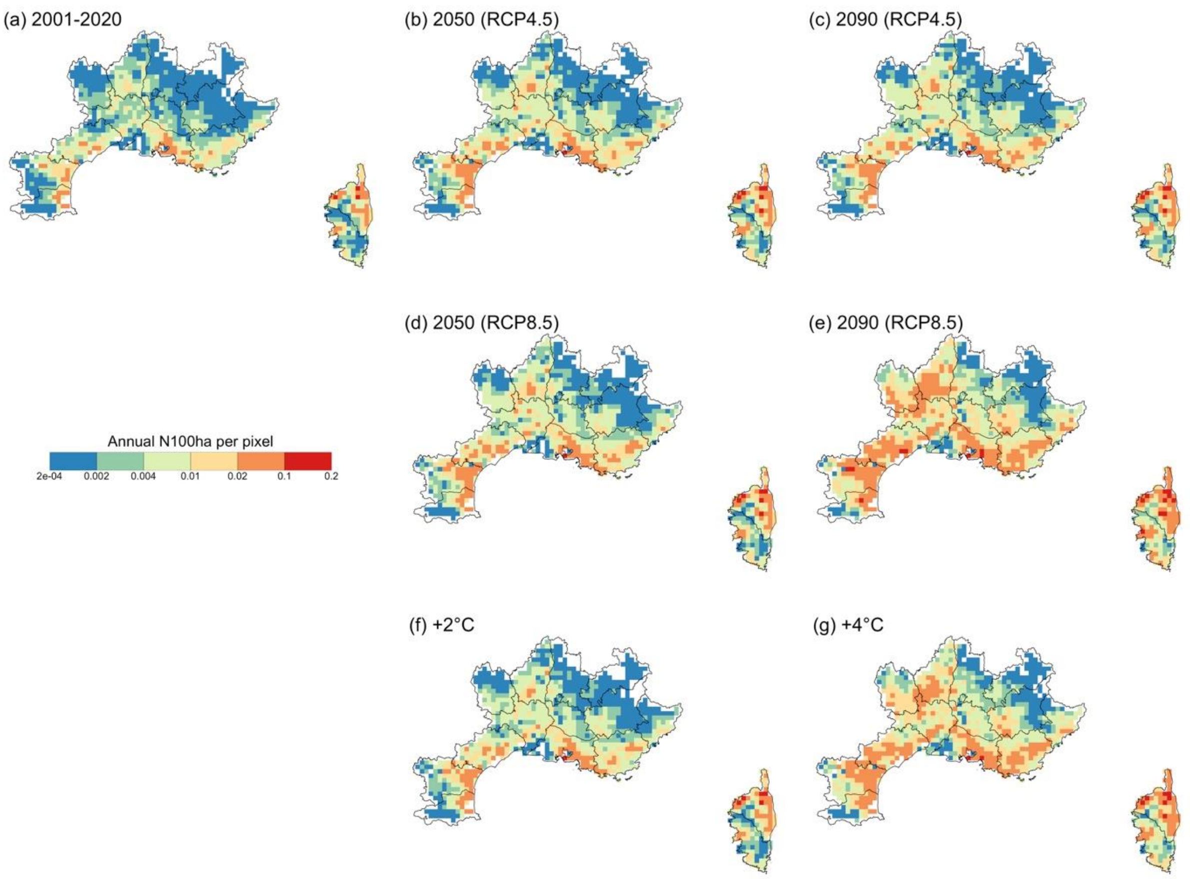

Figure S6. Same as S5 for N100ha.

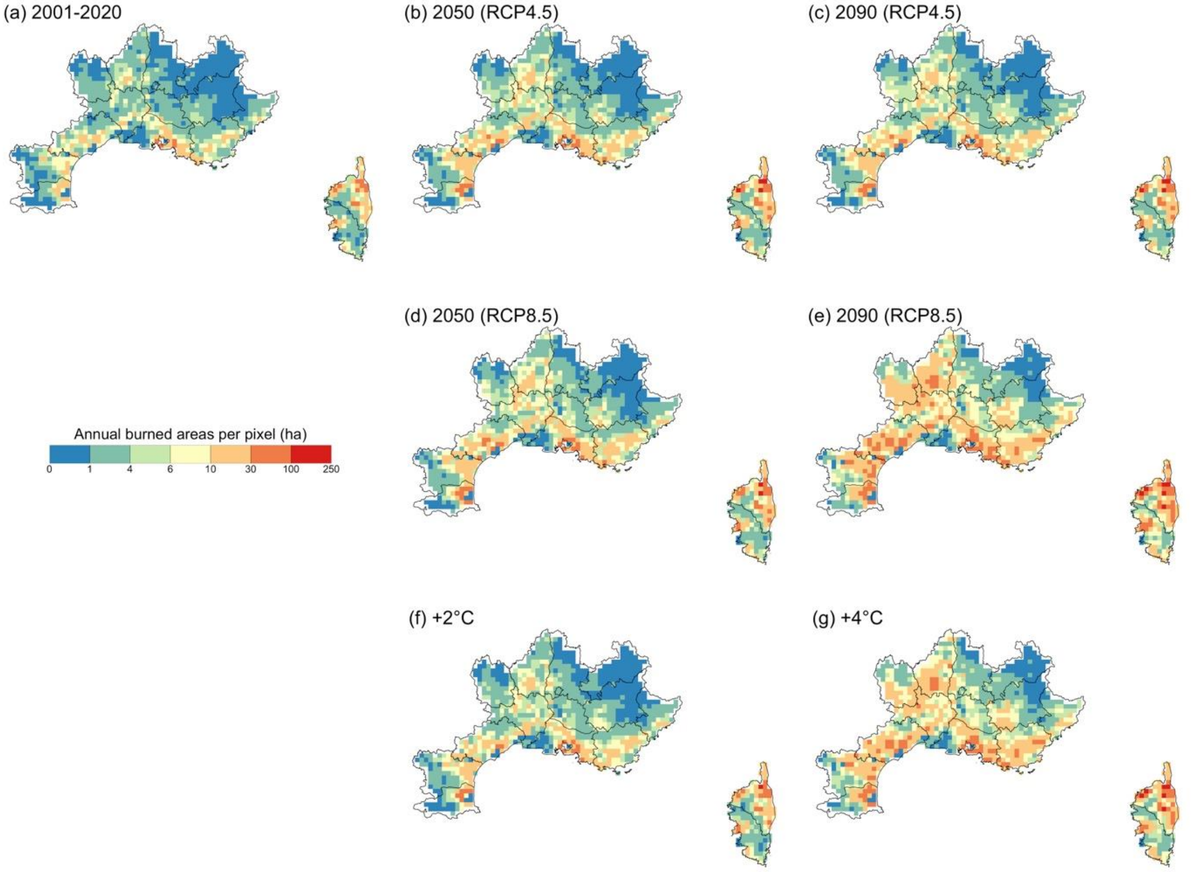

Figure S7. Same as S5 for burned areas.