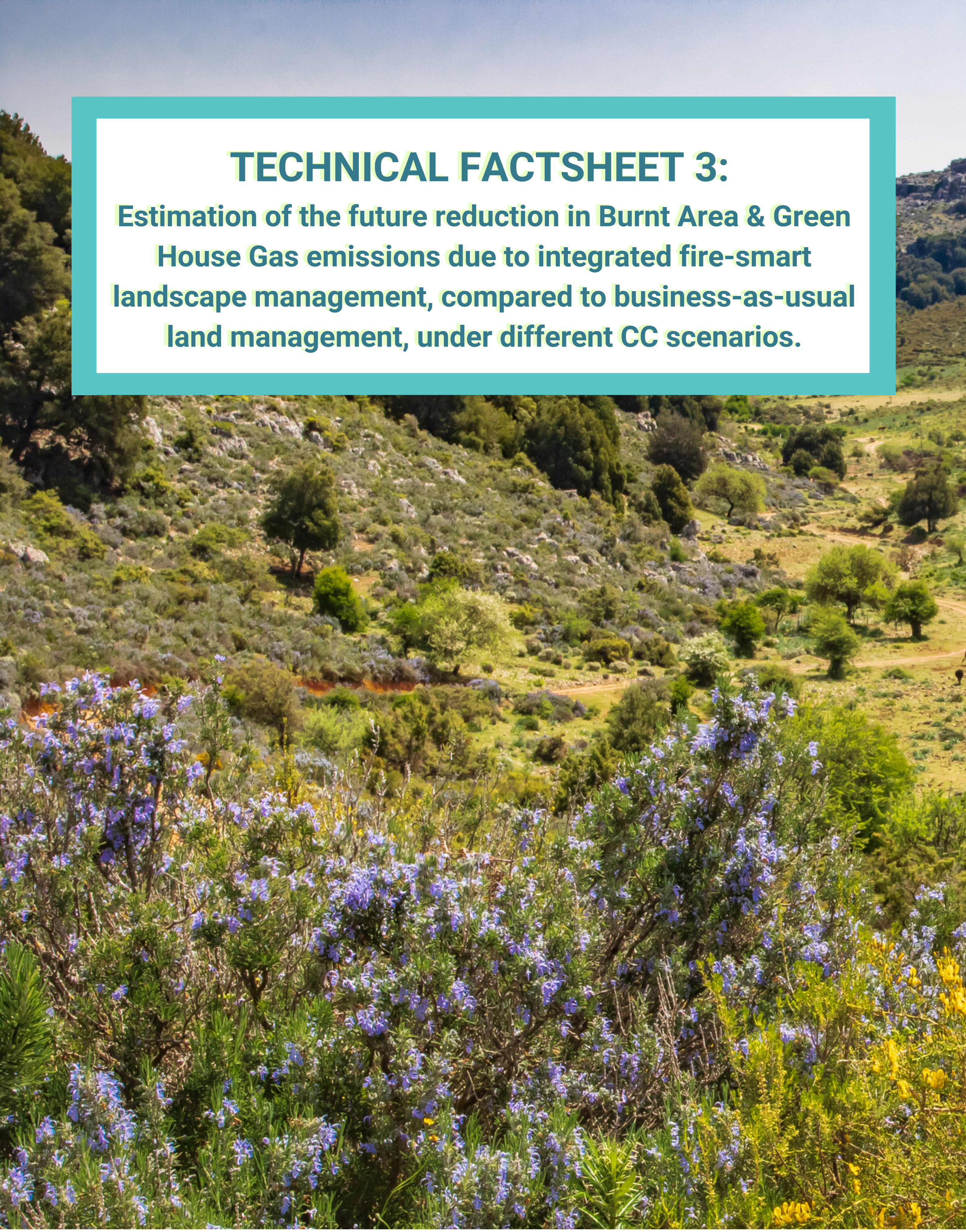
TECHNICAL FACTSHEET 3:

Estimation of the future reduction in Burnt Area & Green House Gas emissions due to integrated fire-smart landscape management, compared to business-as-usual land management, under different CC scenarios.



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Authors

Tim van der Schriek, Anna Karali, Konstantinos V. Varotsos, Christos Giannakopoulos (National Observatory of Athens - NOA)

Layout

Erika Stellini (Istituto Oikos ETS)

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1. Introduction

The **MediterRE3** project provides projections of wildfire related Burnt Area (BA) and associated Green House Gas (GHG) emissions, under different scenarios of future climate change and fire-smart landscape (FSL) interventions, for three different Mediterranean target landscapes. The project aims to support national climate change mitigation, and climate-resilient landscape planning policies & strategies.

The results of **Work package II** ("Development and application of a robust science-based methodology for estimating the reduction in fire-related GHG emissions under future climate change scenarios in fire-smart, mosaic-like resilient landscapes") are summarised in technical factsheets No's 1-3.

The **current technical factsheet** (No 3, WPII, activity AII.3) presents future estimations of BA and GHG emissions for the three target areas (Fig. 1), under different landscape management scenarios that are outlined in factsheet 1. We use the methodology outlined in factsheet 2 for estimating BA & GHG emission from simulated climate and fire-indices. Future projections are derived from state-of-the-art climate models, developed within the EURO-CORDEX initiative.
In this factsheet, the methodology is presented first (section 2), followed by the introduction of the results (section 3).

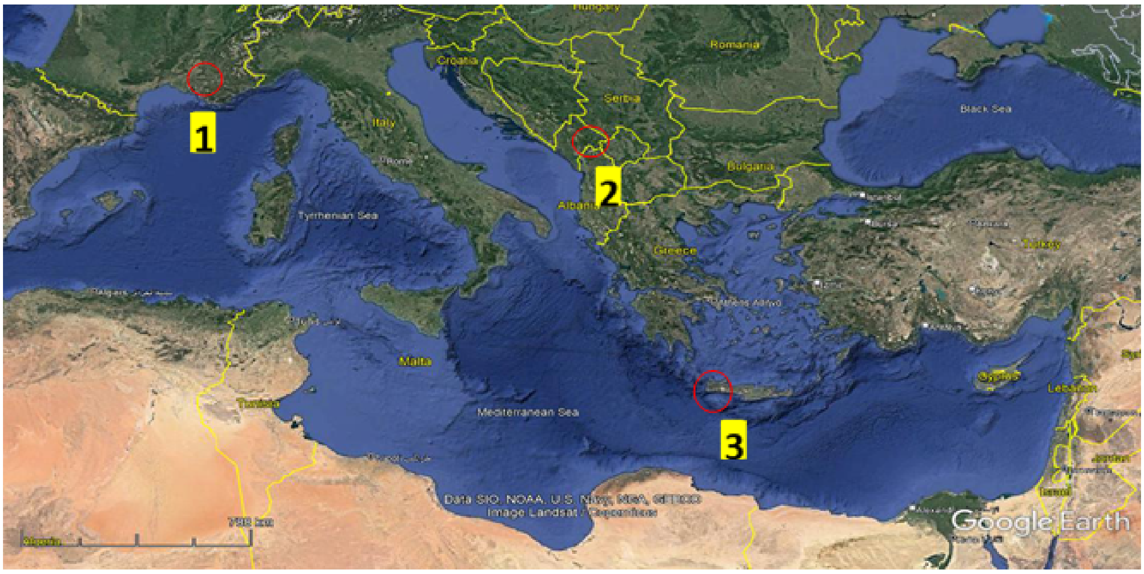

Figure 1: *Location of the target areas selected for fire-smart management interventions (1. Luberon-Lure NP, SE France; 2. Prokletije/Komovi NP, SE Montenegro; 3. Samaria NP, W Crete, Greece).*

2. Methodology

Novel statistical models (see factsheet 2 for discussion) are used to estimate future BA and associated GHG emissions for each target study area. Future wildfire BA and associated GHG emissions are calculated under **three future climate change scenarios** (i.e., Representative Concentration Pathways (RCPs) 2.6, 4.5 and 8.5; Fig. 2.1) and with **business-as-usual management**, up to 2070. State-of-the-art climate models, at a horizontal resolution of 12km developed within the EURO-CORDEX initiative, simulated future climate data that drive BA & GHG-emission estimates (Table 2.1).

Subsequently, numerical correction factors (explained in factsheet 1; see Table 2.2) are applied to the future BA simulations, under different climate scenarios, to derive the **potential reduction** in fire GHG emissions for landscapes under fire-smart management.

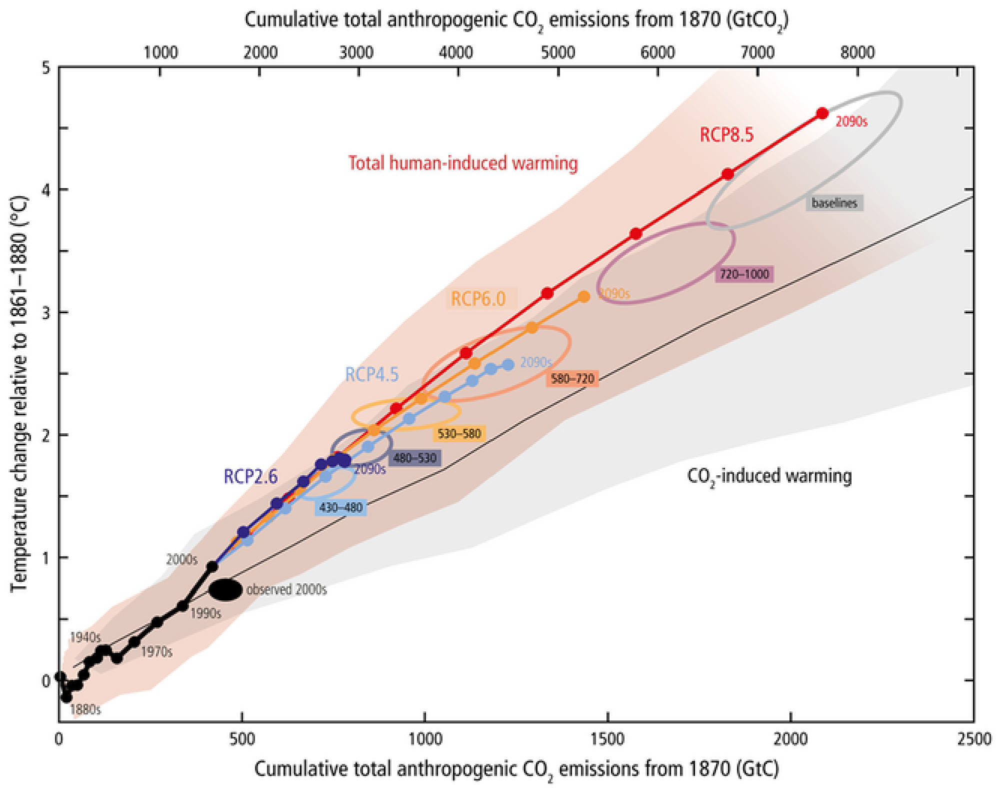

Figure 2.1*: Representative Concentration Pathways (RCPs) used in this study are RCP2.6 (ambitious mitigation policies), RCP4.5 (moderately ambitious mitigation policies), and RCP8.5 (business as usual, no mitigation). Currently, pathways RCP4.5 is considered the most likely (up to 2,5oC warming by 2090s).*

EURO-CORDEX GCM/RCM pairs (hor. Resolution ~12km)

Institute	RCM	GCM
Swedish Meteorological and Hydrological Institute (SMHI)	RCA4	ICHEC-EC-EARTH
Swedish Meteorological and Hydrological Institute (SMHI)	RCA4	MPI-M-MPI-ESM-LR
Swedish Meteorological and Hydrological Institute (SMHI)	RCA4	MOHC HadGEM2-ES

Table 2.1*: Climate models used in this study. Reference period: 1971-2000, Future period: 2011-2070.*

Study Area	Reduction in annual BA, under:	
	2% FSL interventions	5% FSL interventions
Samaria NP (Crete, Greece)	-3.2%	-7.9%
Luberon-Lure NP(France)	-4.7%	-11.8%
Prokletije NP (Montenegro)	-5.6%	-13.9%

Table 2.2: *numerical estimates of the effectiveness of fire-smart interventions in reducing annual BA for each of the target landscapes.* ***Annex A*** *details the data and methodology behind these estimates. The effect of these interventions is relatively low, compared to detailed FSL-impact studies (see factsheet 1). The effects of our 5% FSL intervention scenarios are in line with published FSL-impact studies, albeit at the lower end.*

3. Results

The results are presented in box plots (Figs. 3.1 – 3.27) for each of the target study area and briefly summarised. In each figure, **"M" = mean**, and **"Δ" = difference compared to control** period. Mean Burnt Area (BA) in hectares and GHG-emissions (in Gigagrams; Gg) are rounded to the nearest whole number, as only these integers are statistically significant.

3.1. Chania Province, Crete

Figure 3.1 shows that future fire danger (based on the Fire Weather Index, *hereafter*: FWI) is set to increase; the multi-monthly average over the fire-season (JJAS) is above FWI 35 (high fire danger). The average 6-month drought index is becoming progressively more negative in the future (Fig. 3.2), while the average maximum monthly temperature will increase significantly over the future fire season (Fig. 3.3).

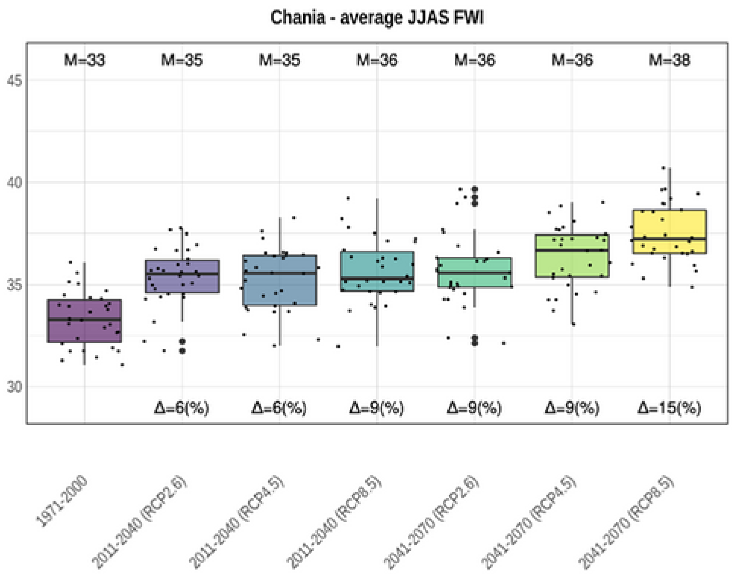

Figure 3.1*: Future FWI*

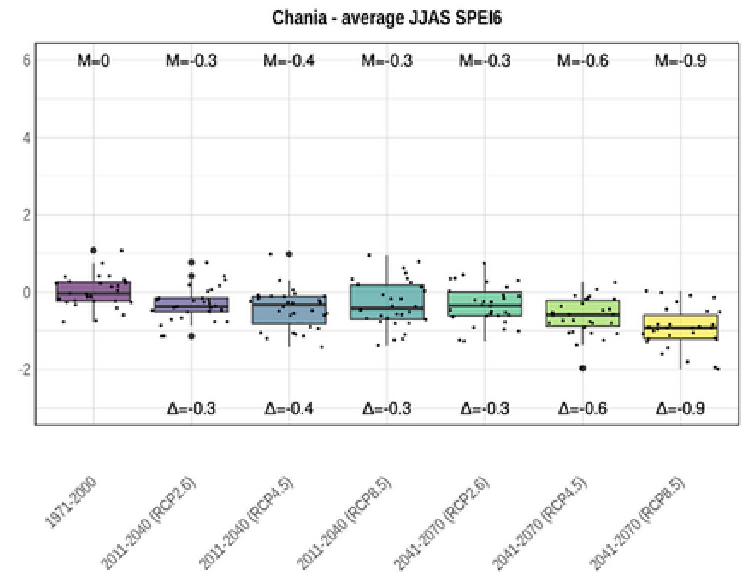

Figure 3.2: *Future SPEI-6*

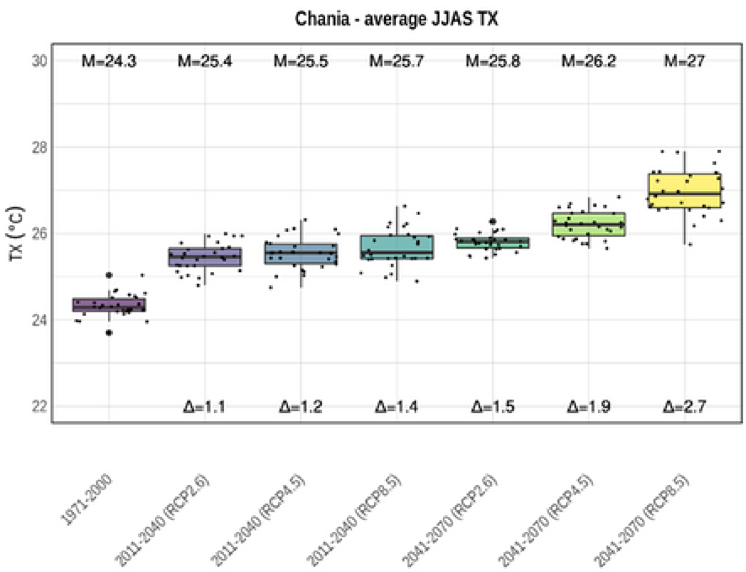

Figure 3.3: *Future T max*

Figure 3.4 indicates that BA will increase by **15-20%** in the near future (2011-2040) and by **18-25%** in the more distant future (2041-2070). As values of BA in the fire season (JJAS: 96,1%) and outside the season (JFMAM and OND: 3,9%) are assumed to be stable (see factsheet 2), the percentage-increases stated here are assumed to be valid on an annual basis.

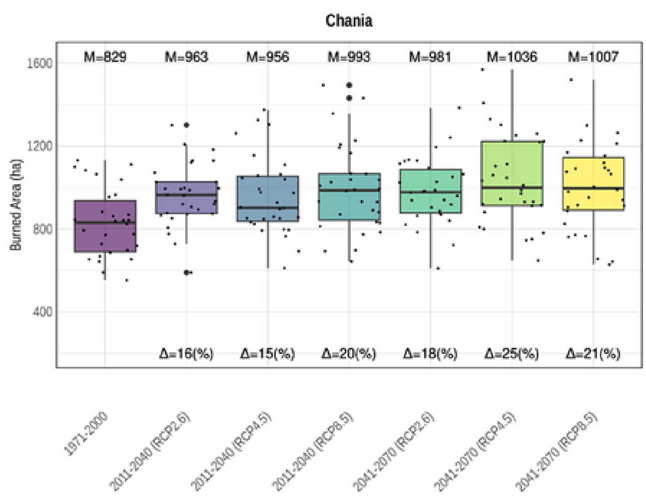

Figure 3.4: *Future BA*

Figure 3.5 indicates that total emissions will increase by **about 17%** under all scenarios, both in the near future (2011-2040) and in the more distant future (2041-2070).

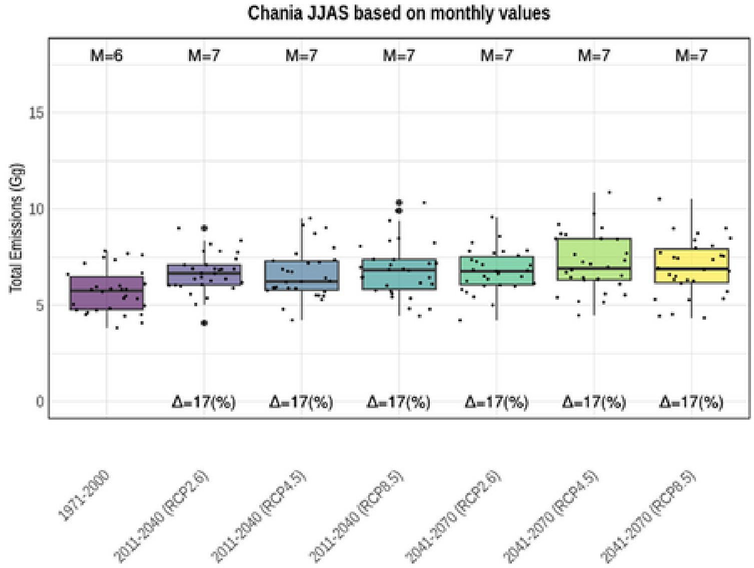

Figure 3.5: *Future emissions*

Figure 3.6 shows **BA** increases of **12-16%** in the near future (2011-2040) and **15-21%** in the more distant future (2041-2070) under a 2% FSL intervention scenario. Figure 3.7 suggests BA increases of **6-10%** in the near future (2011-2040) and of **9-15%** in the more distant future (2041-2070) under 2% FSL interventions.

Figures 3.8 and 3.9 show the impact of FSL interventions on **emissions**, increasing **17%** under 2% FSL interventions in the more distant future (2041-2070) under all RCP scenarios. Under a 5% FSL intervention scenario, there is only a **17%** increase in the more distant future under RCP4.5.

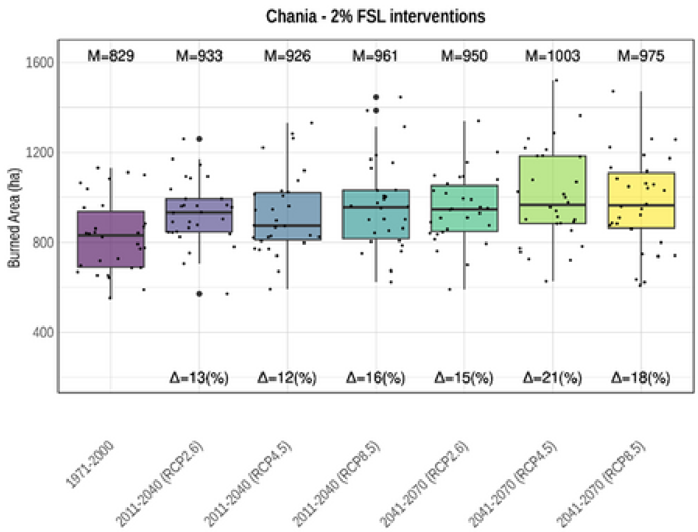

Figure 3.6: *Future BA 2% FSL*

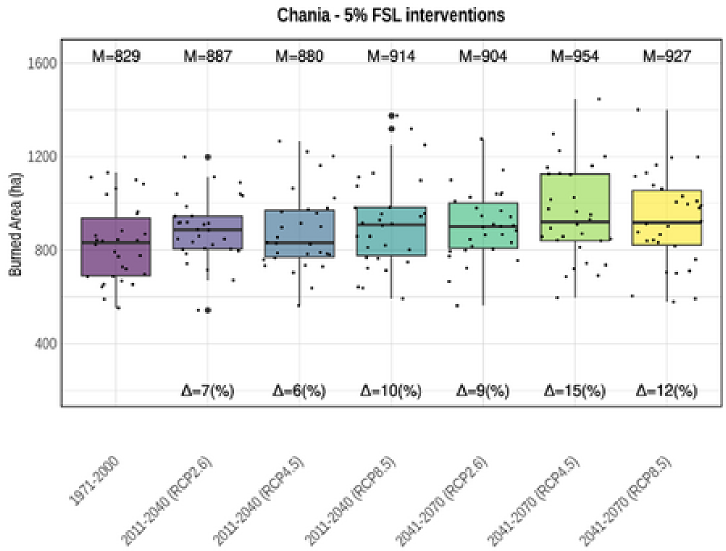

***Figure 3.7**: Future BA 5% FSL*

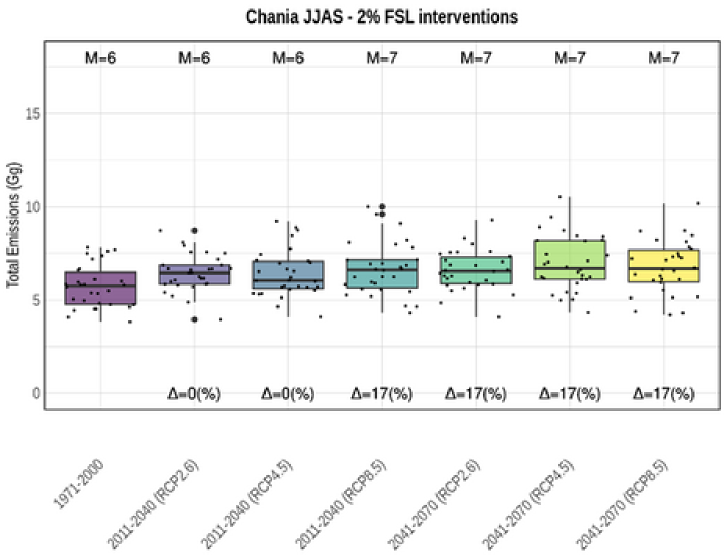

***Figure 3.8:** Future emissions 2% FSL*

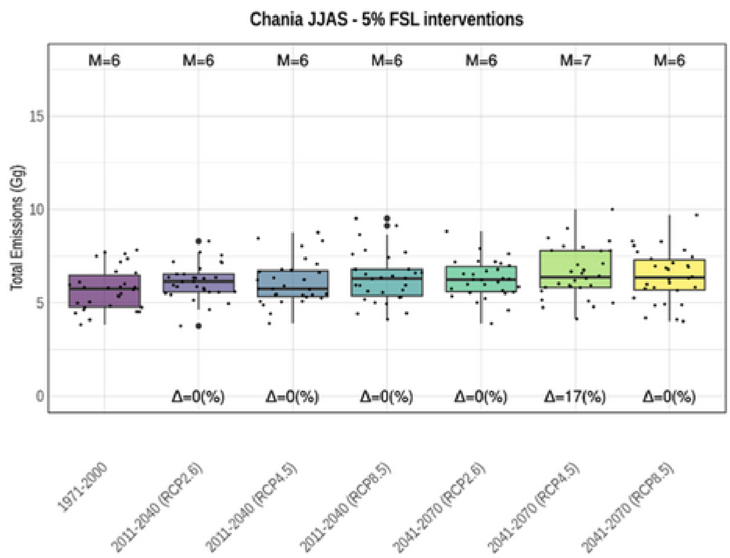

***Figure 3.9:** Future emissions 5% FSL*

3.2. Montenegro

Figure 3.10 shows that fire danger (based on the FWI) is set to increase in the future over the fire-season (JJAS). The average 6-month drought index is becoming progressively more negative in the future (Fig. 3.11), while the maximum average monthly temperature will increase significantly over the future fire season (Fig. 3.12). Note the large variability, especially of future fire danger and Tmax, in the target area.

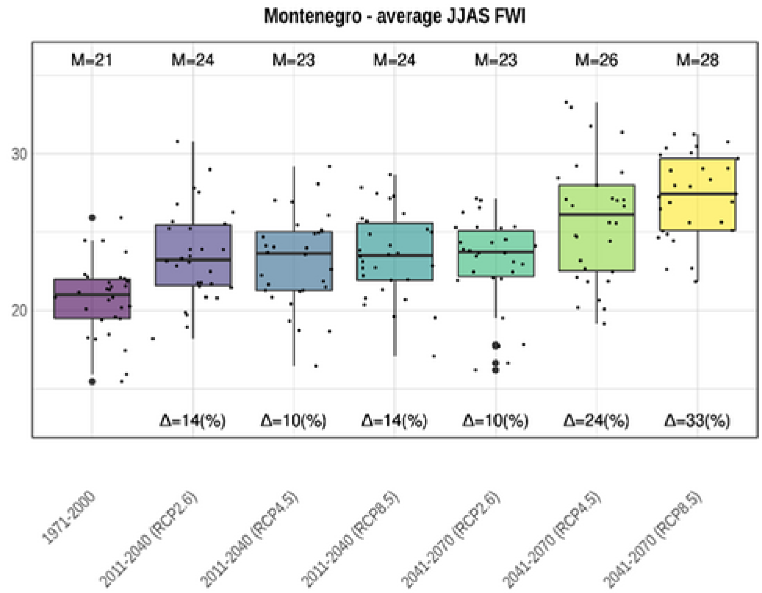

Figure 3.10*: Future FWI*

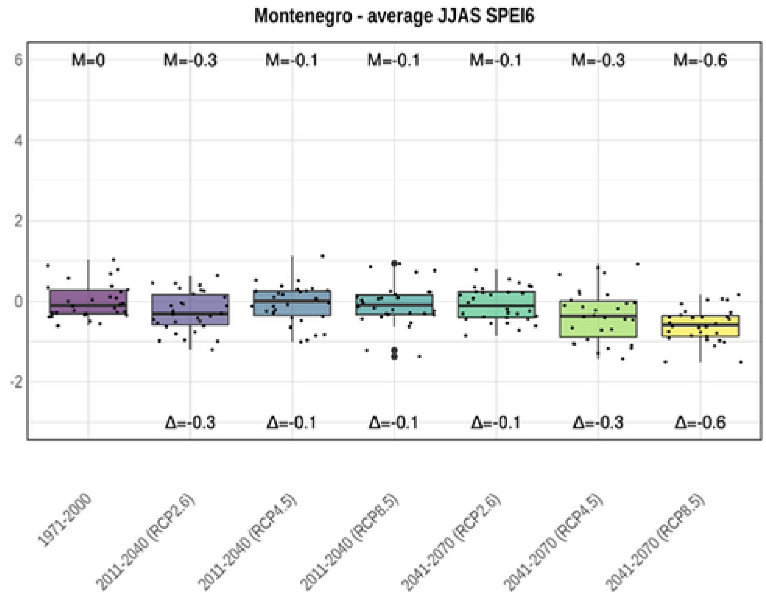

Figure 3.11*: Future SPEI-6*

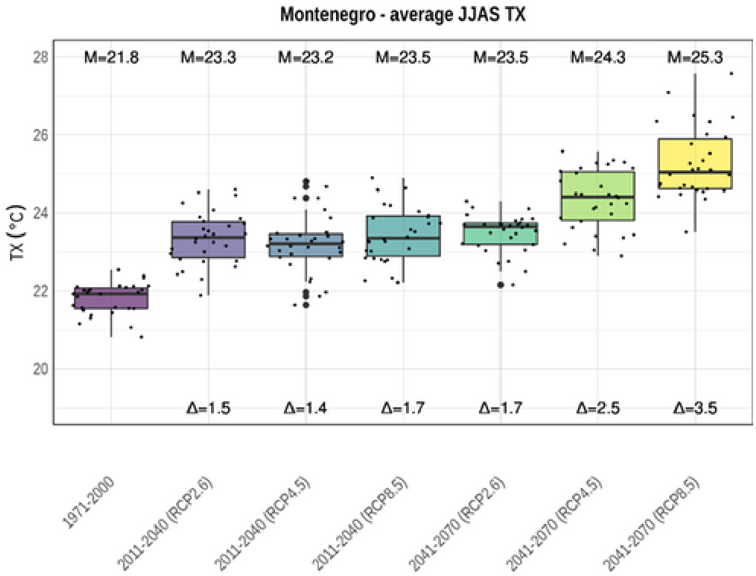

***Figure 3.12**: Future T max*

Figure 3.13 shows a large BA variability under different scenarios in the near future (2011-2040), **from -33% to +47%**; increases in the more distant future (2041-2070) range from **36-127%**. Values of BA occurring in the fire season (JJAS: 93,4%) and outside the season (JFMAM and OND: 6,6%) are assumed to be stable (see factsheet 2); therefore, the percentage-changes stated here are on an annual basis.

Figure 3.14 indicates that total emissions related to wildfire show similar percentual changes as the BA, both in the near future (2011-2040) and in the more distant future (2041-2070).

Note that the Montenegro BA and emissions data are on a coarse-scale (factsheets 1 & 2), and simulated climate data have large variability, which explains the large variability in the future projections (below).

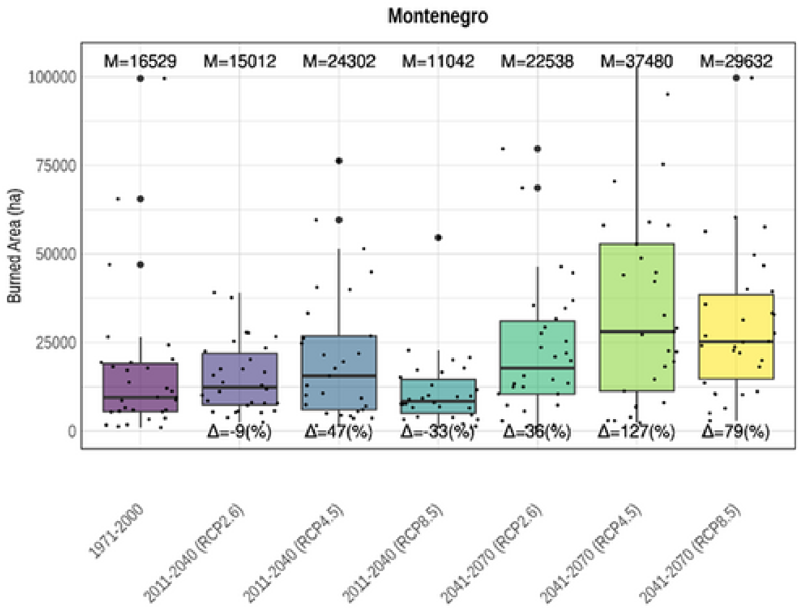

***Figure 3.13**: Future BA*

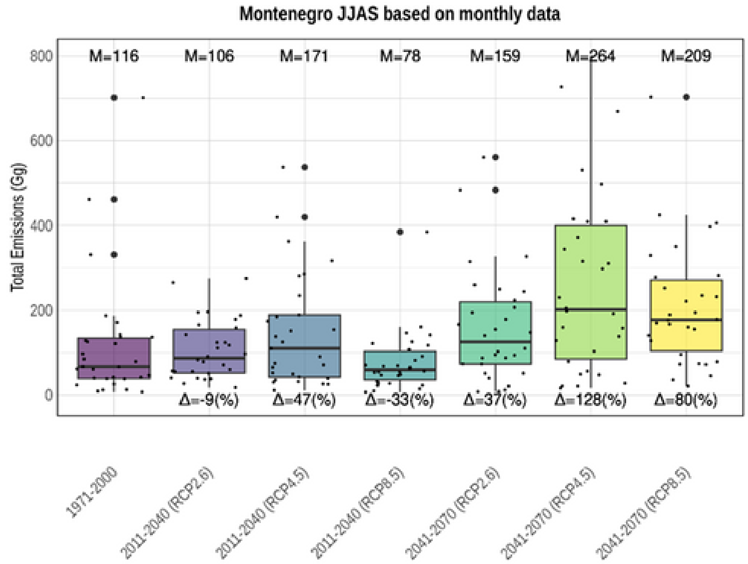

Figure 3.14*: Future emissions*

Figure 3.15 shows BA changes of **-37% to +39%** in the near future (2011-2040) and **+29-114%** in the more distant future (2041-2070) under a 2% FSL intervention scenario. Figure 3.16 suggests BA changes **of -42% to +27%** in the near future (2011-2040) and **+17-95%** in the more distant future (2041-2070).

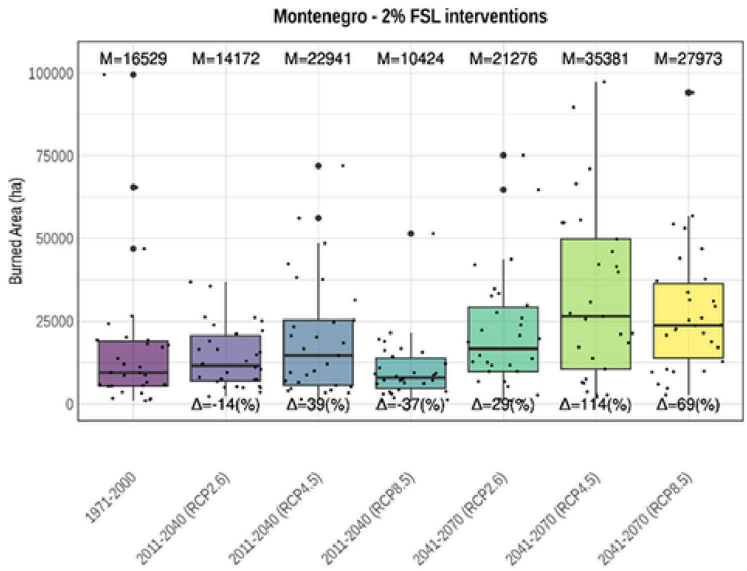

Figure 3.15*: Future BA 2% FSL*

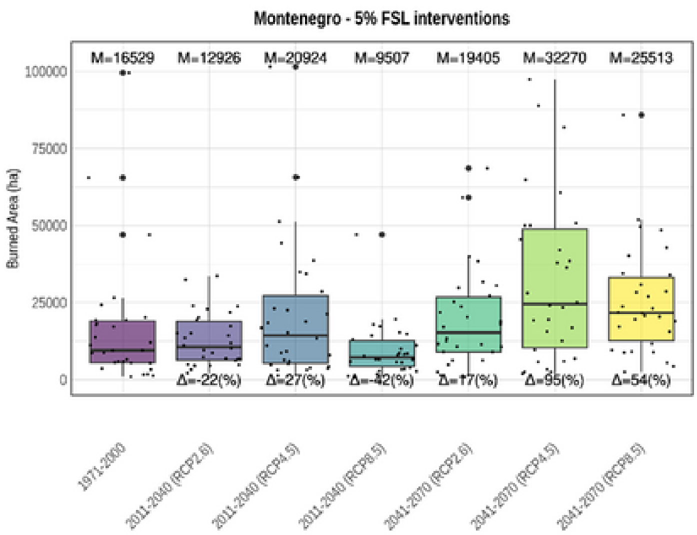

Figure 3.16*: Future BA 5% FSL*

Figures 3.17 and 3.18 show the impact of FSL interventions on emissions, recording changes of **-37% to +40%** and **+19-115%** in the near- and distant future, respectively, under 2% FSL interventions. Under a 5% FSL intervention scenario, there is a change of **-42% to +27%** in the near future, and a **18-96%** increase in the distant future.

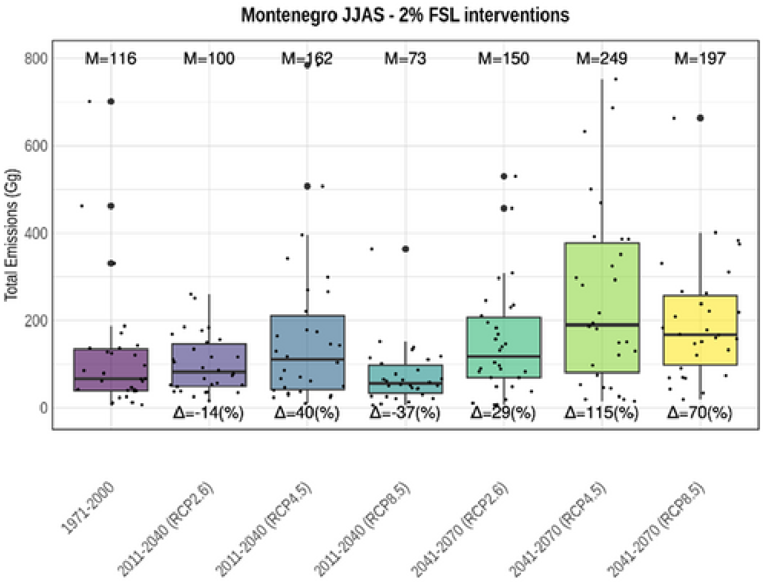

Figure 3.17*: Future emissions 2% FSL*

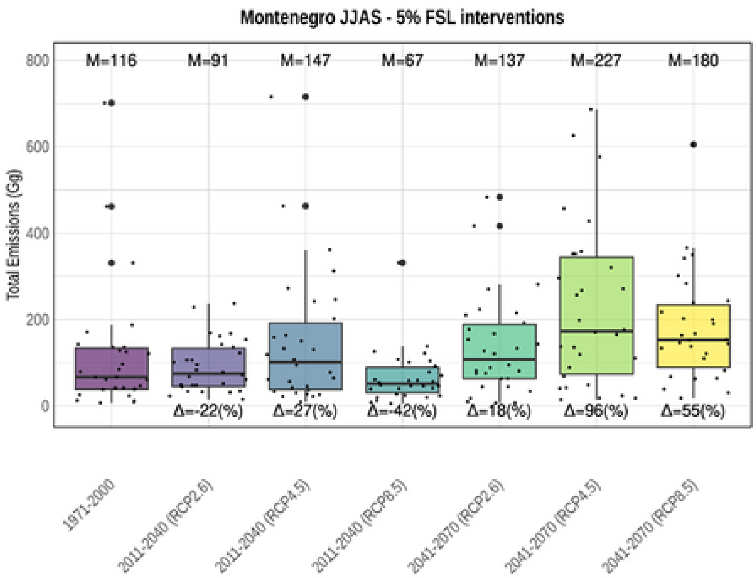

Figure 3.18: *Future emissions 5% FSL*

3.3. Luberon Lure Park, SE France

Figure 3.19 shows that fire danger (based on the FWI) is set to increase over the fire season in the future, especially under RCP4.5 and RCP8.5 in the more distant future (2041-2070). The average 6-month drought index is becoming progressively more negative in the future (Fig. 3.20), while the maximum average monthly temperature will increase significantly over the future fire season, especially under RCP4.5 and RCP8.5 in the more distant future (Fig. 3.21). Note the large variability, especially of future fire danger, in the target area.

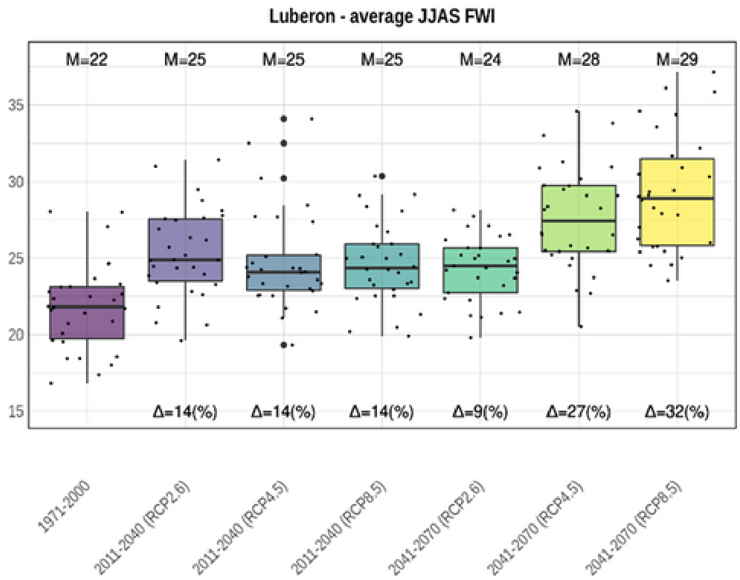

Figure 3.19*: Future FWI*

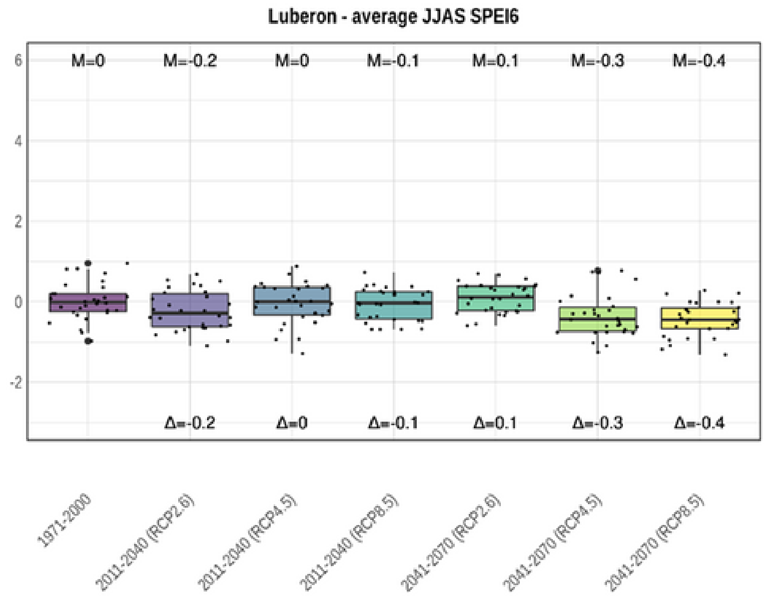

Figure 3.20*: Future SPEI-6*

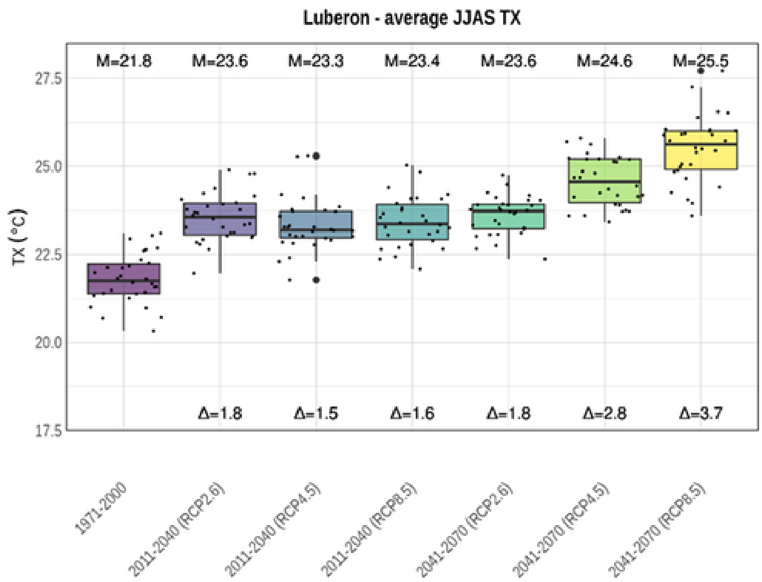

***Figure 3.21**: Future T max*

Figure 3.22 shows BA **increases of 38-40%** in the near future (2011-2040) and **32-111%** in the more distant future (2041-2070). Values of BA occurring in the fire season (JJAS: 91,3%) and outside the season (JFMAM and OND: 8,7%) are assumed to be stable (see factsheet 2). Therefore, the percentage-increases stated here are on an annual basis.

Figure 3.23 indicates that total emissions will **increase by about 100%** under all scenarios (from 1 Gg to 2 Gg). Note that these are rounded averaged increases (no numbers behind the comma).

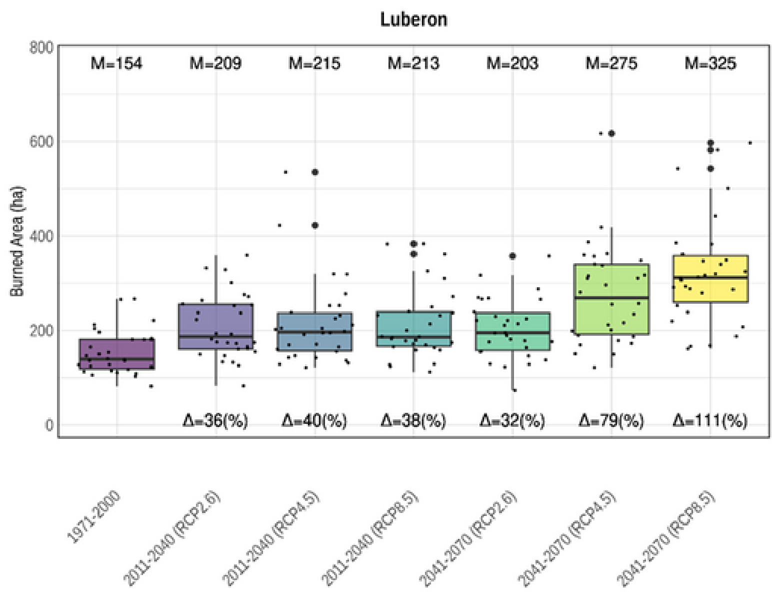

***Figure 3.22**: Future BA*

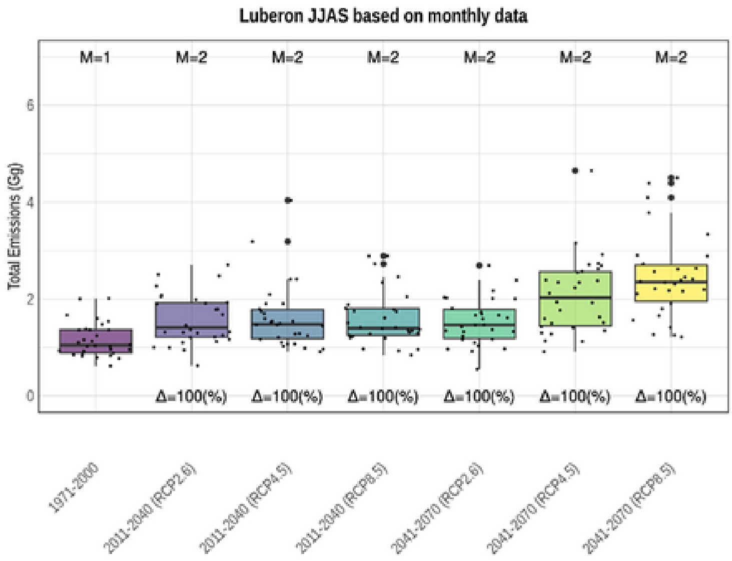

Figure 3.23: *Future emissions*

Figure 3.24 shows that BA will increase **by 29-33%** in the near future (2011-2040) and by **26-101%** in the more distant future (2041-2070) under a 2% FSL intervention scenario. Figure 3.25 suggests BA **increases of 22-26%** in the near future (2011-2040) and of **19-90%** in the more distant future (2041-2070) under a 5% FSL intervention scenario.

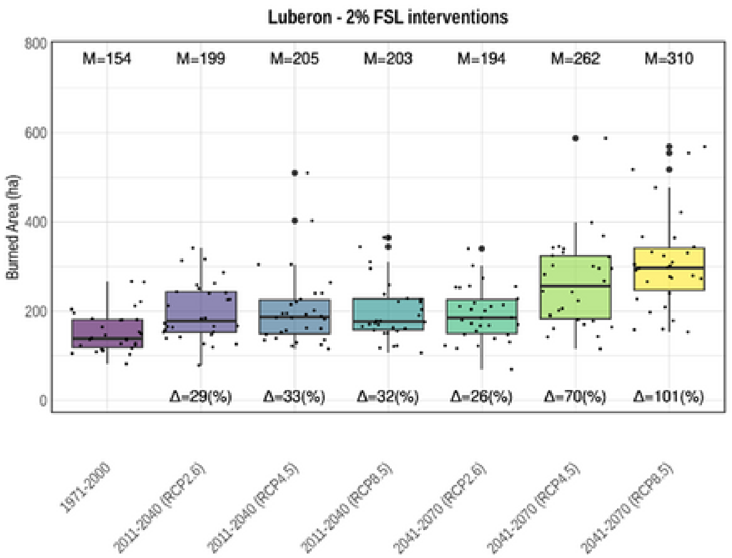

Figure 3.24: *Future BA 2% FSL*

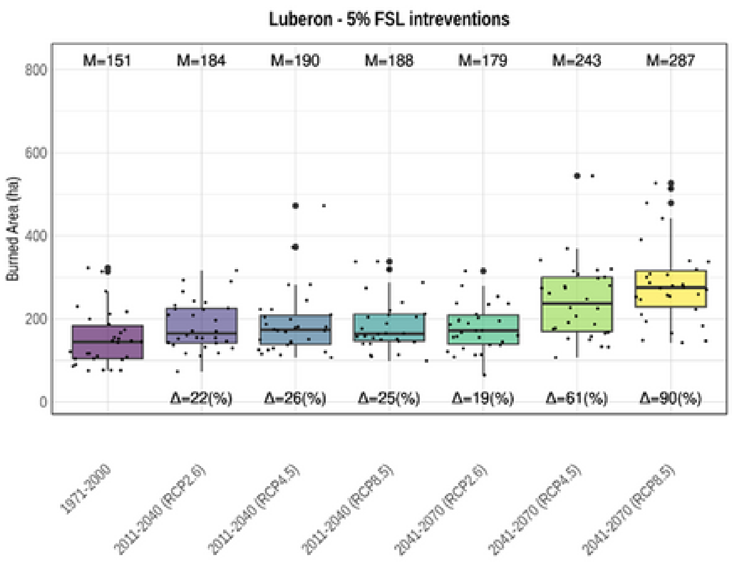

Figure 3.25: *Future BA 5% FSL*

Figures 3.26 and 3.27 show the limited impact of FSL interventions on emission increases. Thus, total emissions will increase by about 100% under all scenarios (from 1 Gg to 2 Gg), except for RCP2.6 (no increase). Note that these are rounded averaged increases (no numbers behind the comma).

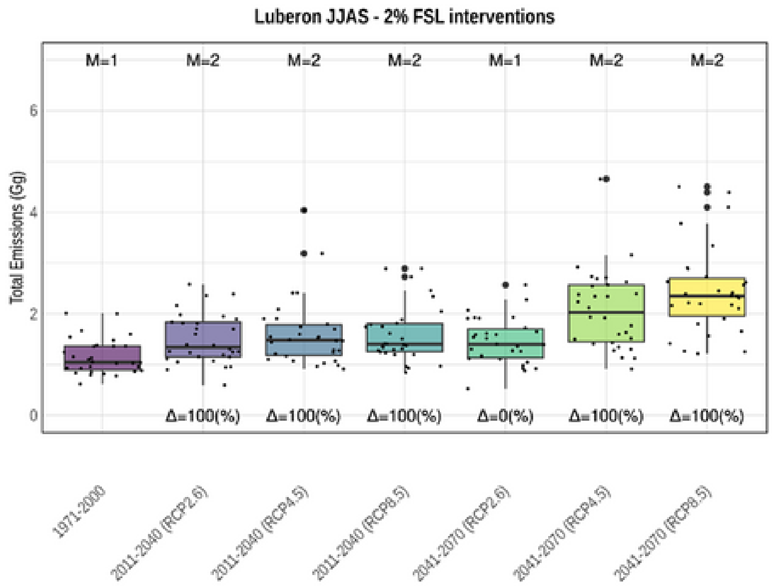

***Figure 3.26**: Future emissions 2% FSL*

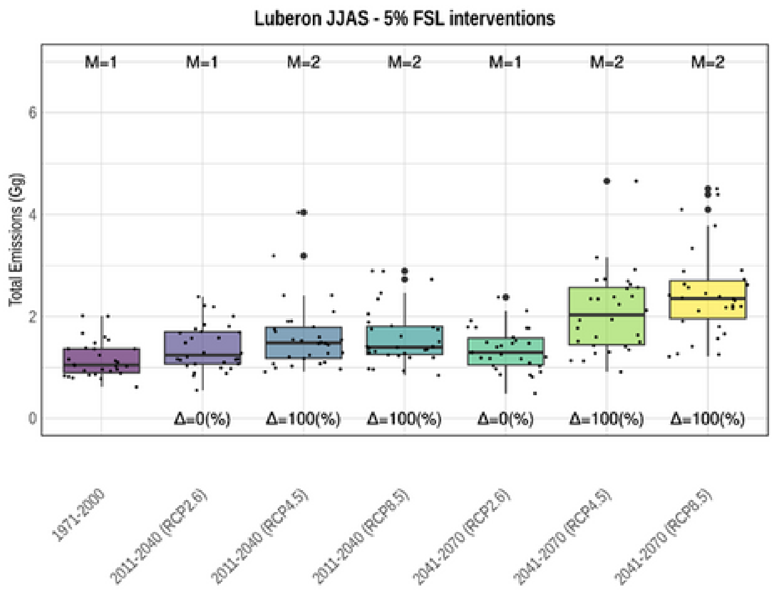

***Figure 3.27**: Future emissions 5% FSL*

4. Discussion & Conclusions

The 2% and 5% FSL management intervention scenarios can be interpreted as the lowest possible impact and the average impact, respectively, of any fire-smart landscape management interventions. Even the impact of the 5% FSL intervention scenario is low, compared to the effect indicated by published studies (see discussion in factsheet 1).

	BA change		Emissions change	
	near future (2011-2040)	**distant future (2041-2070)**	**near future (2011-2040)**	**distant future (2041-2070)**
Chania – no change	15-20%	18-25%	~17%	~17%
Chania – 2% intervention	12-16%	15-21%	~17% (only RCP8.5)	~17%
Chania – 5% intervention	6-10%	9-15%	0	~17% (only RCP4.5)
Montenegro – no change	-33% to +47%	36-127%	-33% to +47%	36-127%
Montenegro – 2% intervention	-37% to +39%	29-114%	-37% to +40%	19-115%
Montenegro – 5% intervention	-42% to +27%	17-95%	-42% to +27%	18-96%
Luberon – no change	38-40%	32-111%	~100%	~100%
Luberon – 2% intervention	29-33%	26-101%	~100%	~100% (0% RCP2.6)
Luberon – 5% intervention	22-26%	19-90%	~100% (0% RCP2.6)	~100% (0% RCP2.6)

Table 4.1*: Projected future BA and emissions associated with wildfires in the target study areas.*

Over the observational period, **~0,63%** of the surface area of Chania Province burned annually, on average. Emissions from wildfires are about **6 Gg over 2.376 km ^{2}(0,25 Gg/km ^{2})**. Future increases in BA of 18-25% (2041-2070) under a no management change scenario are significantly less (by 9-15%) under 5% FSL interventions. Future CC-related emission increases of about 17% may be largely avoided under a 5% FSL intervention scenario (Table 4.1).

About **1,23%** of the total surface area of Montenegro burned annually, on average, over the observation period. Emissions from wildfires are relatively high and amount to **116 Gg over 13.812 km ^{2} (0,84 Gg/km ^{2})** due to the large amount of forest burning. Under a no management change scenario, future BA is projected to increase by 36-127% (2041-2070). However, under 5% FSL interventions BA increases are significantly less at 17-95%. Future CC-related emission increases of 36-127% may be reduced to 18-96% under a 5% FSL intervention scenario (Table 4.1).

On average, **0,08%** of the total surface area of the Luberon-Lure area burned annually over the observation period. Due the relatively small annual BA, emissions from wildfires are low at **1 Gg over 2.308 km ^{2}(0,04 Gg/km ^{2})**. Future BA is projected to increase by 32-111% (2041-2070) under a no management change scenario; this increase is like Montenegro. Under 5% FSL interventions BA increases are significantly less at 19-90%, which is again very similar to Montenegro. Future CC-related emissions do not significantly decrease under FSL intervention scenarios, except for RCP2.6 which shows no increases under a 5% FSL intervention (Table 4.1). However, total future emissions are still very low compared to the other target areas, even under a 100% emission increase.

The increases in BA and GHG emissions from wildfires under future climate change are larger in the Luberon-Lure and Montenegro (which have similar percentage-increases) than in Chania. This is consistent with published studies that expect the largest climate change impacts on BA and GHG emissions from wildfires in the Northern Mediterranean and Mediterranean mountains. Here, much larger biomass is present and climatic variables strongly increase fire danger [**1-3**]. In Chania, fire danger over the very season is already very high, there are frequent fires and a lower biomass. The impact of CC is therefore more limited.

FSL management interventions have a **significant influence** on **reducing the future increases** in BA and GHG emissions from wildfires. Future BA increases are reduced by up to 40-50% for Chania, by 25-50% for Montenegro and 20-35% for the Luberon. Future GHG emissions from wildfires are not increasing (Chania), or the increase is reduced by up to 22-50% (Montenegro). In the case of the Luberon, the decrease is non-significant; however, this is likely an artefact of the very low initial GHG emission values in this target area.

5. References

Amatulli G., Camia A., and San-Miguel-Ayanz J., 2013. Estimating future burned areas under changing climate in the EU-Mediterranean countries. Science of the Total Environment 450–451, 209–222.
http://dx.doi.org/10.1016/j.scitotenv.2013.02.014

Turco M., von Hardenberg J., Agha-Kouchak A., Llasat M.C., Provenzale A., and Trigo R.M., 2017. *On the key role of droughts in the dynamics of summer fires in Mediterranean Europe*. Nature Scientific Reports, 7:81, 1-10.
DOI:10.1038/s41598-017-00116-9

Turco M., Juan José Rosa-Cánovas 2, Bedia J., Jerez S., Montávez J.P., Llasat M.C., and Provenzale A., 2018. Exacerbated fires in Mediterranean Europe due to anthropogenic warming projected with nonstationary climate-fire models. Nature communications, DOI: 10.1038/s41467-018-06358-z.