Effects of fire on soil respiration in Mediterranean forests

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Background

- Soil respiration (SR) is a key process in the C cycle, driven by microbial and root activity.
- In Mediterranean ecosystems, increasingly frequent and severe wildfires alter soil structure, chemistry, and microbial communities, affecting SR.
- Understanding how fire modifies soil microbiological activity affecting CO_2 fluxes and the soil response to moisture and temperature — is essential to predict carbon dynamics and ecosystem resilience.

RQ1: Once environmental factors and soil chemistry are accounted for, does SR depend on soil microbiological activity across different Mediterranean ecosystems?

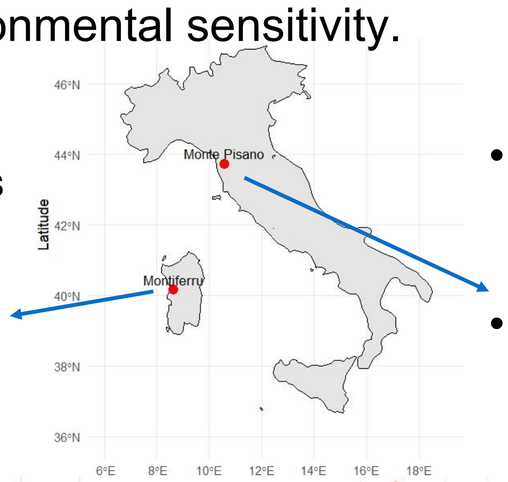
RQ2: Does fire change the relationship between SR, environmental factors and soil Extracellular Enzyme Activity (EEA)?

Methods

- The study was carried out in two Mediterranean mountain areas of Italy.
- Sampling plots were established in burned and unburned areas aiming to minimize environmental variability (slope, elevation, bedrock type)
- The selected sites represent typical Mediterranean forest ecosystems, affected by recurrent wildfires.
- At Mt. Pisano, plots were classified according to fire history: **C**ontrol (i.e. unburned), 1 fire, and 2 fires.
- At Montiferru, sampling included mixed (**MB, MC**) and oak (**QB, QC**) forests, each with burned and control plot.

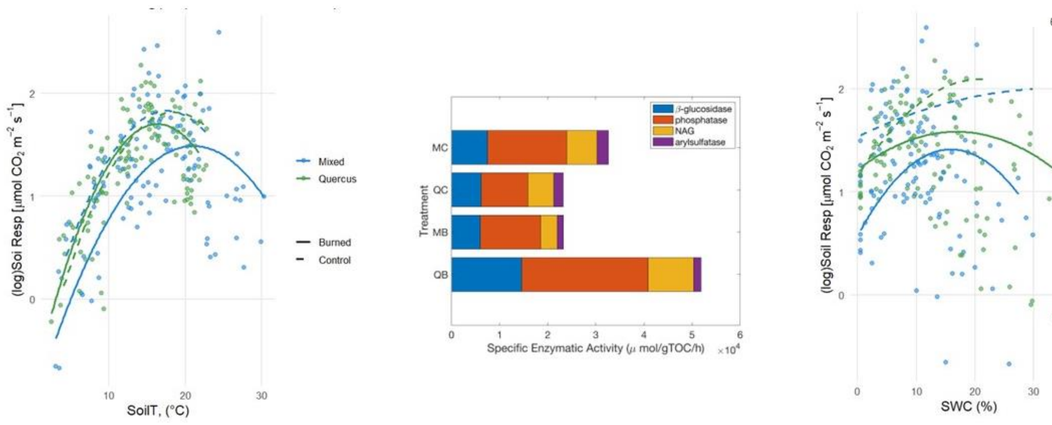
Key Findings

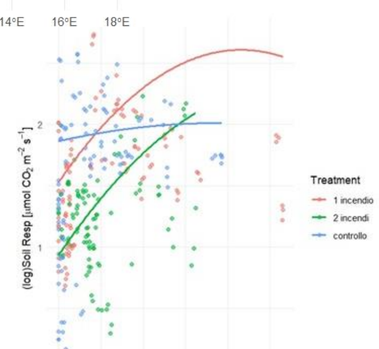
- Fire overall reduced total SR, but site-specific responses to soil temperature (Ts) and soil water content (SWC) revealed different environmental controls on CO_2 fluxes.
- Fire overall affected SoilT and SWC response thresholds, influencing both soil respiration (SR) and enzymatic activity (EEA), with site-specific differences in environmental sensitivity.

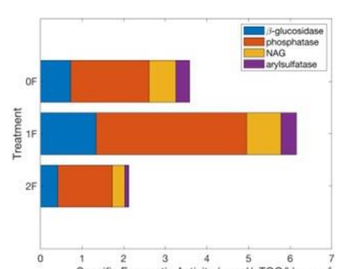


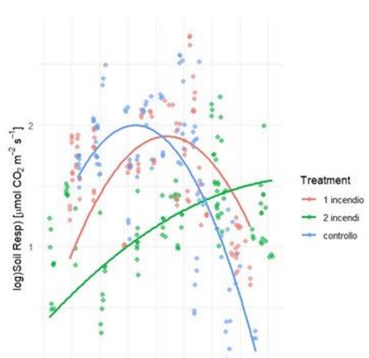
- MB showed higher SoilT and SWC thresholds and lower EEA than MC.
- QB showed lower SoilT and SWC thresholds and higher EEA than QC

- SoilT and SWC thresholds increased with fire frequency — higher values in 2F and intermediate in 1F, compared to controls 0F.
- EEA was highest in 1F, lower in 0F, and lowest in 2F.









- **Treatment** (MB, MC, QB, QC): not significant overall (p = 0.21)
- **SoilT and SoilT^2**: strong non-linear effects (p < 0.001)
- **SWC and SWC^2**: significant effects (p < 0.001 and p = 0.0001)
- **Interactions**: Treatment × SWC and Treatment × SWC^2 significant (p = 0.027 and p = 0.046)
- **Interactions**: Treatment × SoilT^2 marginal (p = 0.084)
- **Model fit**: R^2m = 0.68, R^2c = 0.70; AIC = 333

Contrast	Estimate	SE	p-value
MC – MB	+0.50	0.096	< 0.0001
QB – QC	−0.21	0.097	0.12

Treatment	SoilT (°C)	SWC (%)
Mixed Burned	21.03	15.93
Mixed Control	17.61	29.96
Quercus Burned	16.38	16.83
Quercus Control	18.52	21.08

- **Treatment (0F, 1F, 2F):** significant overall (p = 0.005)
- **SoilT and SoilT^2:** strong non-linear effects (p < 0.001)
- **SWC:** significant effect (p < 0.001); **SWC^2** marginal (p = 0.083)
- **Interactions:** Treatment × SoilT and Treatment × SoilT^2 highly significant (p < 0.001)
- **Interaction**: Treatment × SWC significant (p = 0.021)
- **Model fit:** R^2m = 0.59 R^2c = 0.63 AIC = 361.22

Contrast	Estimate	SE	p-value
1F – 0F	+0.054	0.082	0.79
2F – 0F	−0.594	0.084	< 0.0001
2F – 1F	−0.648	0.080	< 0.0001

Treatment	SoilT (°C)	SWC (%)
0F (Control)	15.68	37.93
1F (1 Fire)	18.46	43.11
2F (2 Fires)	27.86	32.43

Preliminary Conclusion: Fire reduces total SR and modifies temperature and moisture thresholds, indicating changes in soil biological activity (*Zhou et al., 2023; Almagro et al., 2025*).

2nd International Symposium on Biodiversity and Ecosystem Functions under Global Change
12 – 14 November 2025
Alghero (Sardinia – Italy)