Long-term effects on soil forest unmanaged after a wildfire at different fire severities: historical fire at Cadiretes Massif, Catalonia, Spain

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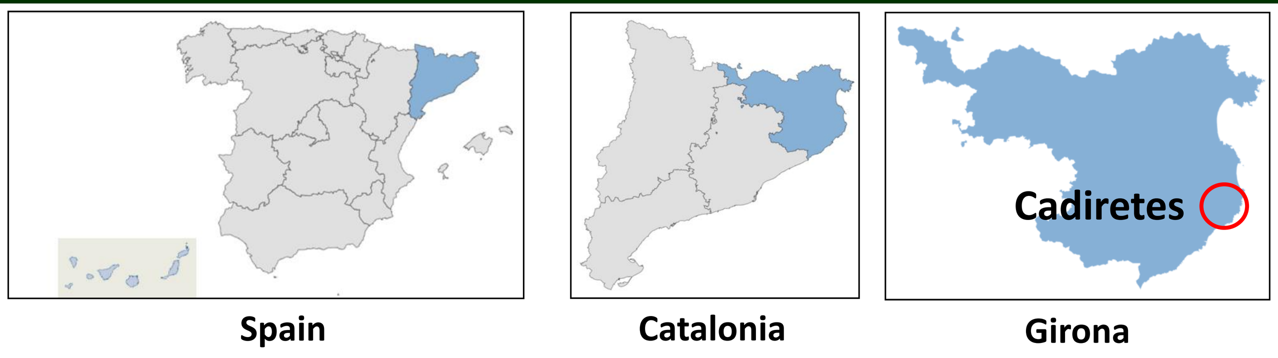
INTRODUCTION

Wildfire is a common disturbance in Mediterranean forests ecosystems. However, during the last decades wildfire frequency and burned surface area have been increasing. The abandon of forest areas by the population, the change of soil uses and climate change are causing wildfires of higher magnitude and difficult to control. The affected ecosystems have several difficulties to recover due to the high temperature reached during those great fires. The effects of fire on burnt soil forests depend on many different factors, such as the intensity of fire, duration, quantity of combustible or recurrence among others. However, the understanding of wildfire effects on soil forests at long-term is still needed to improve. **OBJECTIVE: To monitor the long-term effects (28 years) of a wildfire (55 ha) on soil properties in two areas affected at different fire severities.**

MATERIALS AND METHODS

Study location: Cadiretes Massif, NE Spain (Girona, Catalonia; 41°78'40"N, 2°86'46"E, Fig. 1), with mean annual temperature ≈ 14°C, mean annual precipitation ≈ 750mm and mean annual evapotranspiration rate ≈ 800mm. **Study areas selected the day after the 1994 wildfire** (Fig. 2): unburnt Control area (C); Low Severity wildfire area (LS); High Severity wildfire area (HS). Prior the wildfire, the area was a plantation of *Pinus pinaster ssp*. with some individuals of *Quercus suber L.* **No management has been applied after the wildfire (Fig. 3).**

Figure 1. Location of the study area.



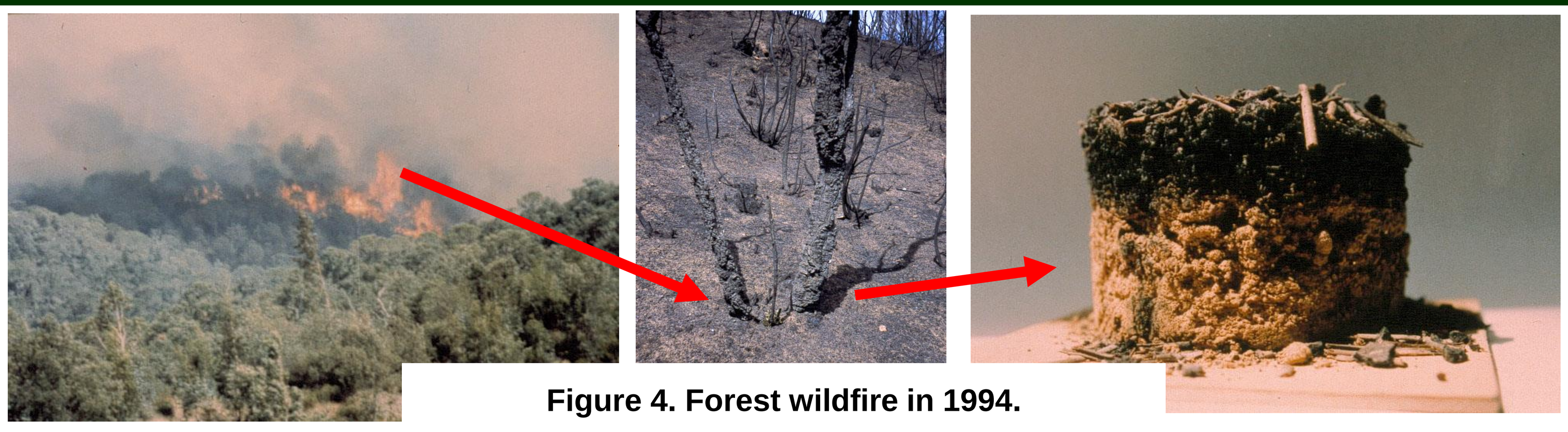


Figure 4. Forest wildfire in 1994.

Just after the fire (Fig. 4). **LS:** The trees retained some leaves, and large number of branches. A considerable amount of litter was deposited. All the *Quercus suber* survived as well as some *Pinus*.

HS: The trees lost all their leaves and branches and only the trunks remained. *Arbutus unedo* also disappeared completely. The soil surface was left totally uncovered, but after the fire and before the first rains a large horizon of grey and white ashes was present.

Figure 2. Study areas in Cadiretes

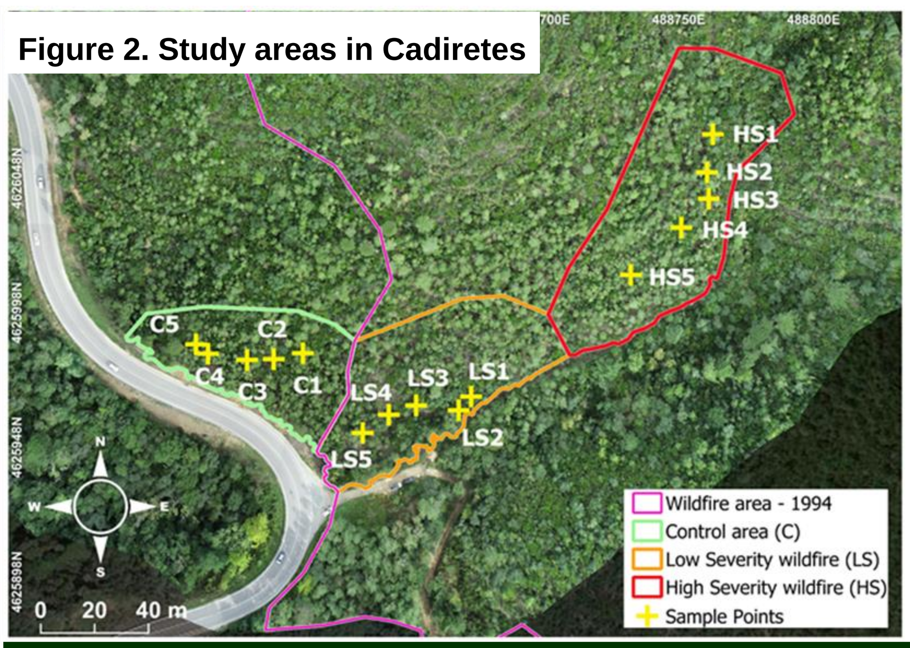


Figure 3. Cadiretes in April 2022

Figure 5. Non-tree biomass: freshly fallen (A), dry litter (B) and humus (C).

Non-tree biomass was collected (1 m^2 per plot, n=5) in three different layers (Fig. 5). Then, the organic material was dried in an oven at 60°C for 48 h and weighted.

1. RESULTS AND DISCUSSION: soil characterization

Table 1. Characterization of the study soils (mean±SE; n=5). pH and EC (µS cm^{-1}) is electrical conductivity in soil:water extracts; soil cations Na^+, Ca^{2+}, Mg^{2+}, K^+ extracted with ammonium acetate (mg kg^{-1}). Different letters indicate significant differences (p< 0.05, Anova with Tukey test).

Environment	pH	EC	Soil extractable cations			
			Na^+	Ca^{2+}	Mg^{2+}	K^+
C	5.1±0.1 a	114±13 b	145±16 a	2955±87 b	588±60 a	242±14 a
LS	5.3±0.2 a	87±6 ab	116±7 a	2681±155 ab	570±57 a	197±17 a
HS	5.4±0.1 a	80±6 a	164±36 a	2337±205 a	615±43 a	294±53 a

The soil pH and extractable Na^+, Mg^{2+} and K^+ concentrations was similar in all the study areas. The EC and extractable Ca^{2+} concentrations was lower in HS than in C, but similar between LS and C. This points to a better recovery of soil conditions in LS than in HS after the wildfire (Table 1).

2. RESULTS AND DISCUSSION: SWR and soil organic indicators

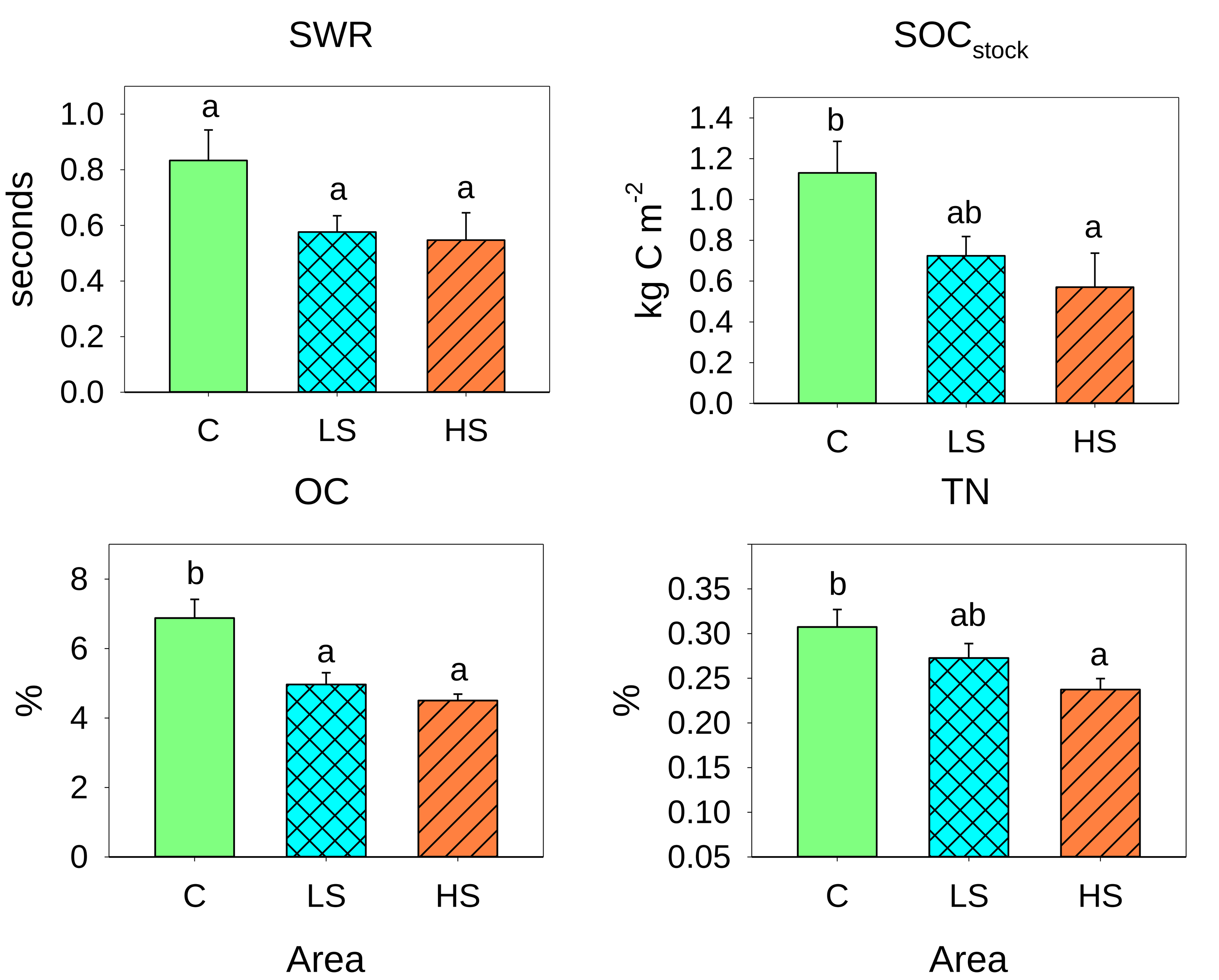
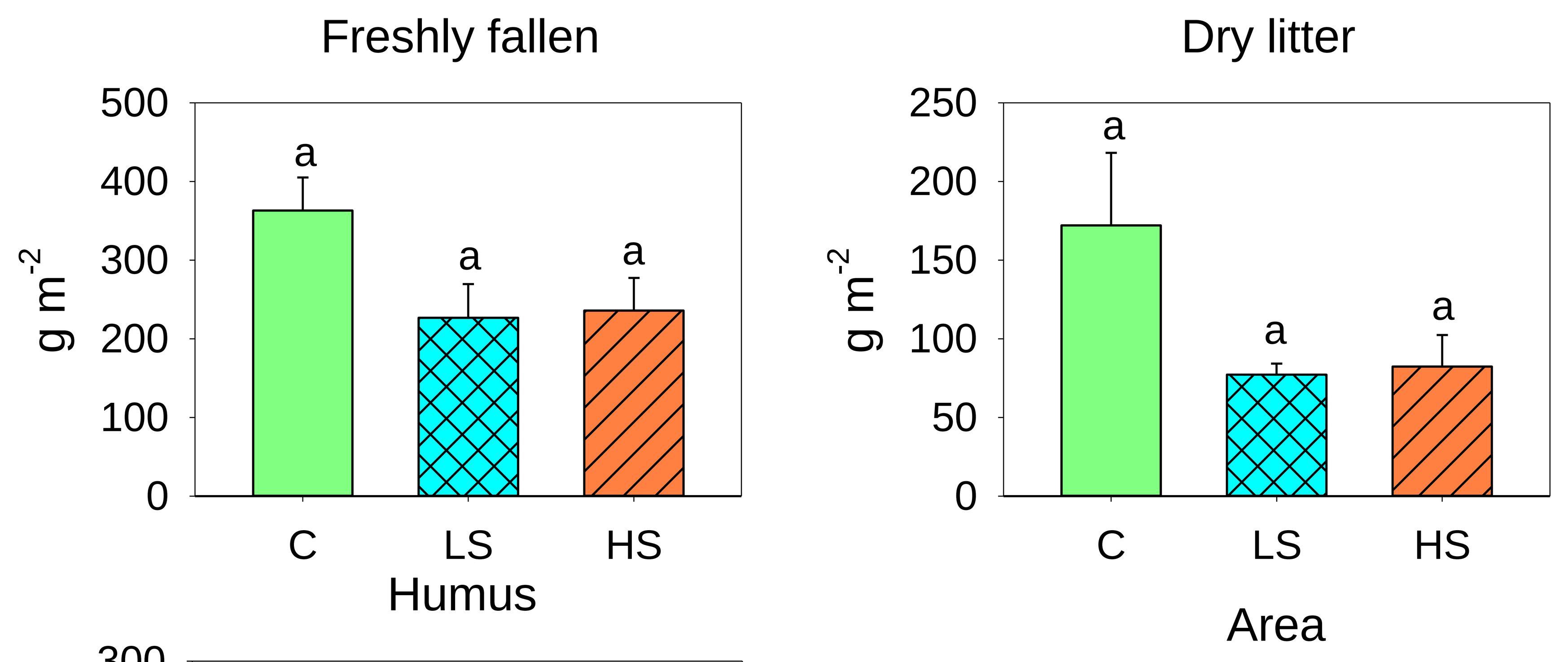
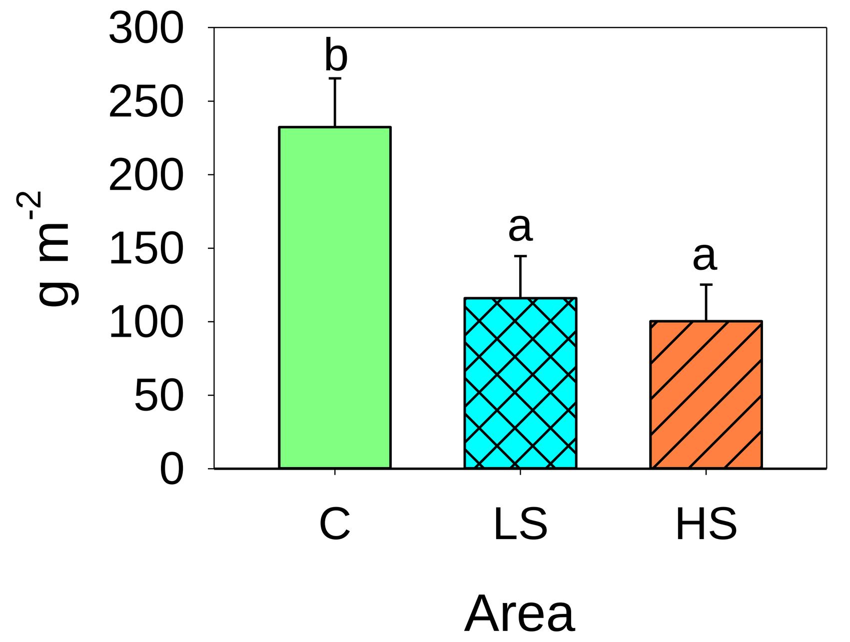


Figure 6. Soil Water Repellency (SWR); Soil Organic Carbon stock (SOC_{stock}); Organic Carbon (OC); and Total Nitrogen (TN) in the study areas. Data are average ± SE (n=5). Different letters indicate significant differences (p< 0.05, Anova with Tukey test).

SWR was slightly higher in C than in LS and HS but without significant differences among them. SOC_{stock}, OC and TN showed similar tendency with higher contends in C than in LS and HS. The content of TN was also higher in C than in HS, with intermediate contends in LS (Fig. 6).

3. RESULTS AND DISCUSSION: Non-tree biomass accumulation





All the studied non-tree biomass types were found in the studied areas, but with differences in the accumulated quantity. Freshly fallen and Dry litter material accumulation was slightly higher in C than in LS and HS, but without significant differences among the study areas. However, Humus material accumulation was significant higher in C than in LS and HS (Fig. 7).

Figure 7. Freshly fallen, Dry litter and Humus biomass accumulation in the study areas. Data are average ± SE (n=5). Different letters indicate significant differences (p< 0.05, Anova with Tukey test).

CONCLUSIONS

These results could indicate that at long-term, soil properties of burnt areas are partially able to recover and reach similar values to those of unburnt areas. However, it also seems that some soil parameters need more time to reach similar values than unburnt areas, especially after high severity fire episodes.

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