EFFECTS OF PRESCRIBED FIRE ON SOIL ORGANIC MATTER, STRUCTURE AND WATER REPELLENCY IN DIFFERENT AGGREGATE SIZES AND DEPTHS

Ortiz-Perpiñá, O[1,3*]; Girona-García, A[1,3]; González-Arribas, A[1]; Badía-Villas, D[1,3]; Martí-Dalmau, C[1,3]; Armas-Herrera, CM[1,3]; Mora-Hernández, JL[2,3]

1.Escuela Politécnica Superior de Huesca, Departamento de Ciencias Agrarias y del Medio Natural, Universidad de Zaragoza, Huesca, Spain *oriol@unizar.es

2.Facultad de Veterinaria, Departamento de Ciencias Agrarias y del Medio Natural, Universidad de Zaragoza, Zaragoza, Spain

3.Instituto Universitario de Investigación en Ciencias Ambientales de Aragón (IUCA), Universidad de Zaragoza, Spain.

INTRODUCTION

The decrease of livestock grazing during the last decades in the Pyrenees has led to a regression of grasslands in favour of shrublands [1] composed, among others, by *Echinospartum horridum*. Prescribed burning might be a suitable tool for the control of this species that limits pastures development and therefore, the reclamation of grasslands; although, its effects on soil properties are still uncertain. Controlled burnings are usually performed in spring or autumn, when soil water content is high and temperature low, being easier to control and also reducing its effects on soil properties [2]. However, burning during the wet seasons can increase the risk of soil erosion as the vegetation cover is partially destroyed and modifications can be induced in important interrelated soil properties as soil organic matter, structure and water repellency [3].

The aim of this work is to analyse the effects of prescribed burning in a subalpine environment on soil organic carbon, structure and water repellency at different depths and aggregate sizes

MATERIAL AND METHODS

SOIL SAMPLING

Prescribed *Echinospartum horridum* burning in Buisán (NE-Spain)

42°36'04.4"N 0°00'43.3"E
1760 masl
MAT (°C): 5.7
MAP (mm): 1270
Calcaric Leptic Cambisol (WRB, 2014)

1. Control sampling (U)
2. Burning
3. Immediate post-fire sampling (B0)
4. Six months post-fire sampling (B6)
5. One year post-fire sampling (B12)

3 sampling points

Sampling depths
0-1 cm
1-2 cm
2-3 cm
3-5 cm

SAMPLES PREPARATION

Air drying until constant weight

Manual sieving separating 6 aggregate sizes:

<0.25 mm
0.25-0.5 mm
0.5-1 mm
1-2 mm
2-4 mm
4-10 mm

LABORATORY ANALYSIS

Mean Weight Diameter (MWD)

Soil Water Repellency (SWR) persistence (Water Drop Penetration Time, **WDPT**)

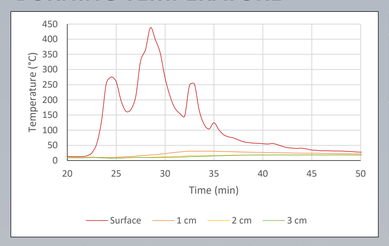
Aggregate Stability (AS): Kemper & Koch (1966).

Soil oxidizable C (OC): Walkley-Black (1934).

Comparison analysis via ANOVA test

Buisán prescribed fire. Please scan the QR code to watch a video of the burning

BURNING TEMPERATURE

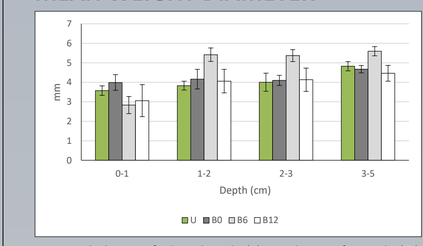


Variables	Surface	1 cm	2 cm	3 cm
Maximum temperature (°C)	438.09	31.08	18.47	18.50
Initial temperature (°C)	13.12	9.77	9.60	8.93
Final temperature (°C)	27.54	22.15	17.55	18.19
Duration (min)				
< 100 °C	17.50	30.00	30.00	30.00
100 - 200 °C	6.00	0.00	0.00	0.00
200 - 300 °C	4.00	0.00	0.00	0.00
300 - 400 °C	2.00	0.00	0.00	0.00
> 400 °C	0.50	0.00	0.00	0.00

Temperature data registered during the prescribed burning via termocouples placed at soil surface and at 1 cm, 2 cm and 3 cm depth.

- A maximum temperature of 438°C was recorded at soil surface while at 1 cm depth only 31°C were reached.
- Only slight increases in temperature were detected below 1 cm soil depth.

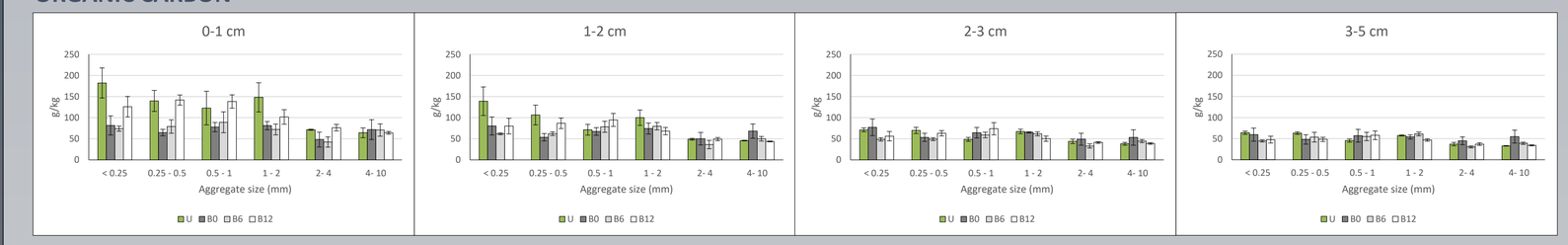
MEAN WEIGHT DIAMETER



Mean weight diameter of unburned samples (U), immediate post-fire samples (B0) 6 months (B6) and one year (B12) post-fire samples at different sampling depths. Mean ± SE.

- MWD of the soil aggregates was lower at 0-1 cm depth (3.6 ± 0.4 mm) than 3-5 cm depth (4.8 ± 0.4 mm) in unburned samples.
- No remarkable changes were detected immediately after fire.
- Six months after burning, MWD 1-2 cm depth aggregates slightly increased as compared to the unburned samples, but this effect disappeared one year after burning.

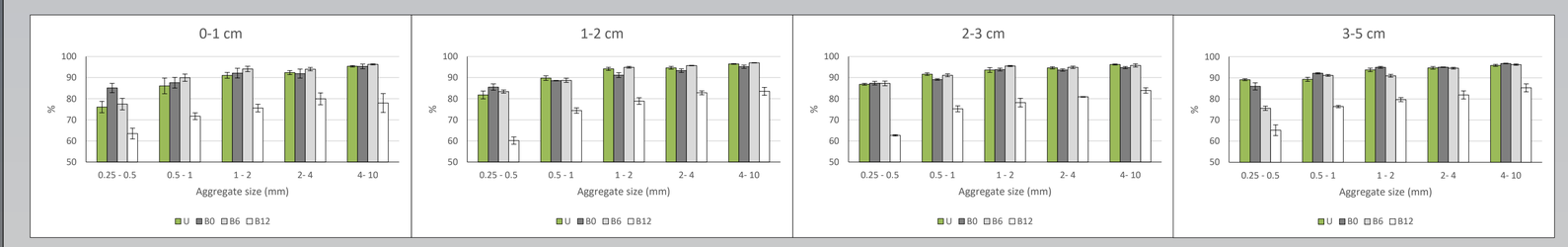
ORGANIC CARBON



Soil organic carbon content of unburned samples (U), immediate post-fire samples (B0), 6 months (B6) and one year (B12) post-fire samples for each aggregate size and sampling depth. Mean ± SE.

- The OC content of the unburned samples shows a steep gradient with depth. The highest OC content was observed in the finer aggregate sizes.
- Fire significantly affected the OC in the first cm of the <0.25 mm aggregates and the first two cm of the 0.25-0.5 mm aggregates, reducing its amount by 49-55 %.
- The pre-fire amounts of OC in the affected soil fractions had been recovered one year but not six months after the fire.

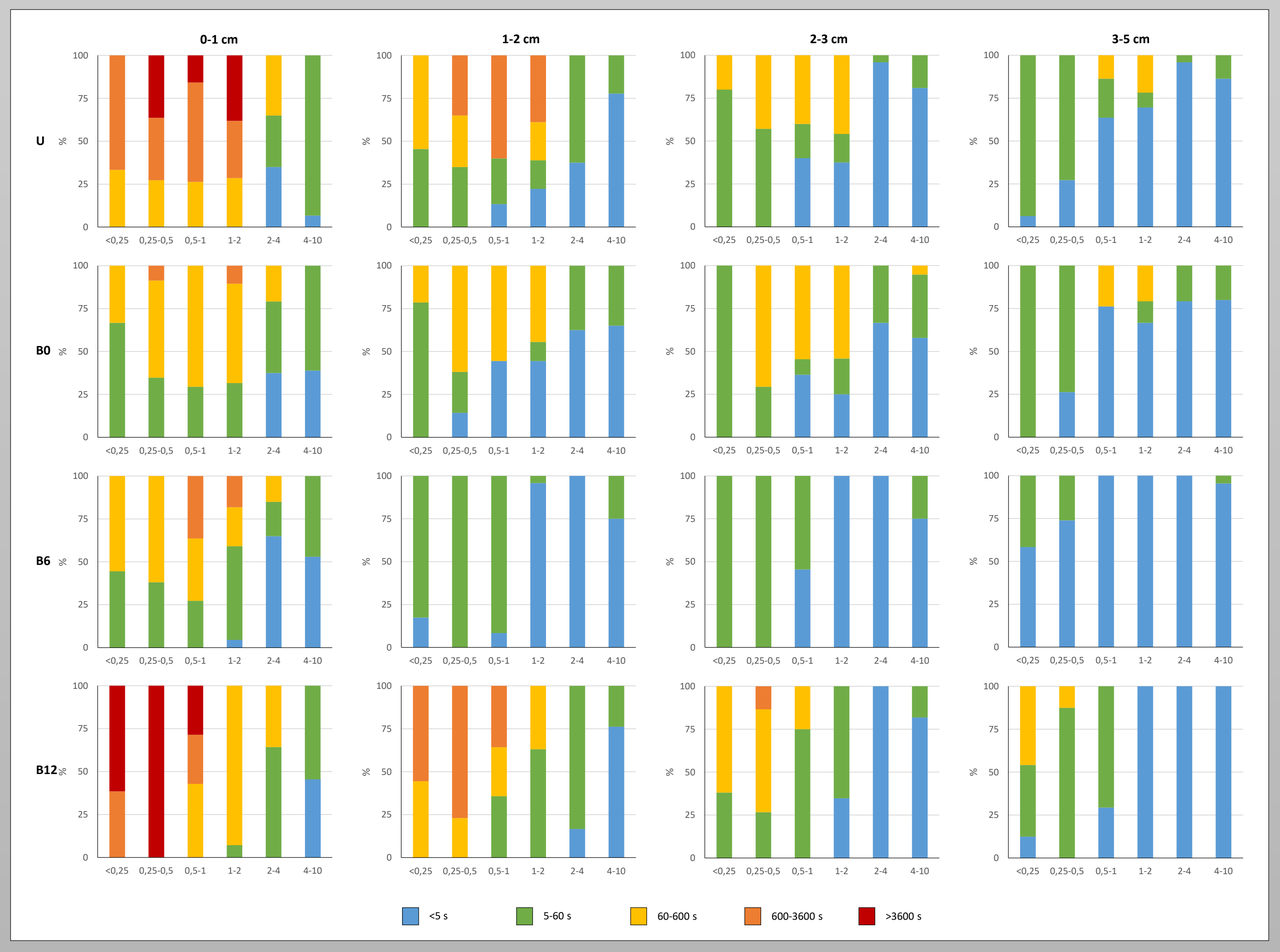
AGGREGATE STABILITY



Aggregate stability of unburned samples (U), immediate post-fire samples (B0), 6 months (B6) and one year (B12) post-fire samples for each aggregate size and sampling depth. Mean ± SE.

- AS was high for unburned and burned samples and all aggregate sizes, with values over 70%.
- Fire effect on AS was only detected in the 0-1 cm depth and affected only the small size aggregates (0.25-0.5 mm) by increasing the AS by almost 12 % of the initial values.
- No significant changes were observed in AS 6 months after the burning.
- One year after fire, the AS was significantly reduced by an average of almost 17% of the pre-burning values at all aggregate sizes and soil depths.

SOIL WATER REPELLENCY



Occurence of soil water repellency (WDPT) in the unburned (U), immediate post-fire (B0), 6 months (B6) and one year (B12) post-fire samples for each aggregate size and sampling depth. SWR clases defined by Bisdom *et al.* 1993 [4]

- A higher degree of SWR was observed for the urburned samples of upper layers.
- SWR occurrence decreases with depth.
- Remarkable decreases in SWR were detected with fire, mainly in the <2 mm aggregates at 0-1 cm depth.
- A slight recovery of SWR can be observed six months after the burning for the first cm.
- Six months after the fire, in deeper soil layers, SWR keeps decreasing as compared to immediately burned samples.
- SWR of the finer fractions (<0.5 mm) further increased one year after burning in the upper layers, and became similar to the pre-burning values at deeper layers and in coarse soil aggregates at all depths.

DISCUSSION

SWR vs. OC: a positive correlation was observed in the U, B6 and B12 samples. In B0, a decrease in both SWR and OC amount was detected and the lack of correlation may indicate a change in OC quality.

SWR vs. AS: a significant negative correlation was found for the U, B0 and B12 samples. This correlation was not detected in B6 samples as SWR began to increase but AS had not changed.

OC vs. AS: despite the remarkable decrease of OC with fire, no changes are observed in AS which indicates that the AS of this soil could be given by the clay content (22%) rather than the OC content. A trampling effect caused by cow grazing may explain the significant decrease in AS one year after the fire, as OC amount keeps increasing at this moment.

CONCLUSIONS

1. **Fire had no effects on the MWD.**
2. **OC content was only significantly reduced by burning in the finer fractions (<0.25 and 0.25-0.5 mm) at 0-2 cm depth. A significant recovery of OC was found one year but not six months after fire.**
3. **Burning increased the AS of the 0.25-0.5 mm aggregates by a 12 % in the first cm. Changes in AS one year after fire could probably be related to a trampling effect and not to fire.**
4. **Unburned samples showed natural SWR at 0-2 cm depth and was reduced by fire mainly in the <2 mm aggregate sizes. SWR increased one year after fire in the naturally repellent samples.**
5. **SWR changes with fire may be rather related to OC composition than its amount.**
6. **Fire only affected the studied soil properties in the finer fractions of the supper layers, but these effects were still detectable 6 months later and only appeared to recover one year after burning.**

REFERENCES: [1] San Emeterio *et al.* (2016). Agric Ecosyst Environ 235:155-163; [2] Úbeda *et al.* (2005). Int. J. Wildland Fire 14: 379-384; [3] Mataix-Solera *et al.* (2011). Earth-Sci. Rev. 109: 44-60; [4] Bisdom *et al.* (1993). Soil Sci 56: 105-118

ACKNOWLEDGEMENTS: This study is part of the results of the FUEGOSOL project (CGL2013-43440-R) funded by the Spanish "Ministerio de Economía y Competitividad". This study was partly funded by the "Diputación de Huesca" *Félix de Azara* research grant. A. Girona-García is funded by a FPI research grant (BES-2014-068072). We thank Rafael de Partearroyo and Raúl Vicente (EPRIF, Huesca) for allowing us to participate in the prescribed fire events.