Effects of prescribed burning on soil fertility and carbon dynamics in pre-littoral Mediterranean mountain pastures

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Introduction

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Pastures are a key factor in the global landscape. They occupy between 26% of the terrestrial surface. They also have a key role in human development. Recently those pastures have been decreasing in the Iberian Peninsula due to abandonment and climate change and being substituted by shrublands.

One of the ways to recover these pastures, traditionally, has been prescribed burning. Prescribed burning (PB) is “the planned use of fire to achieve precise and clearly defined objectives” (Fernandes, 2013). Although it is a used strategy to recover grasslands, we know very little on how the soil is affected by those low intensity fires and the factors involved in the response of the soil.

In this study we have asked ourselves three major questions:

1. How does the soil responds to this perturbation?
2. Are there any legacy effects involving this response?
3. Is this response modulated by the topography of the ecosystem?

Materials and methods: Site description

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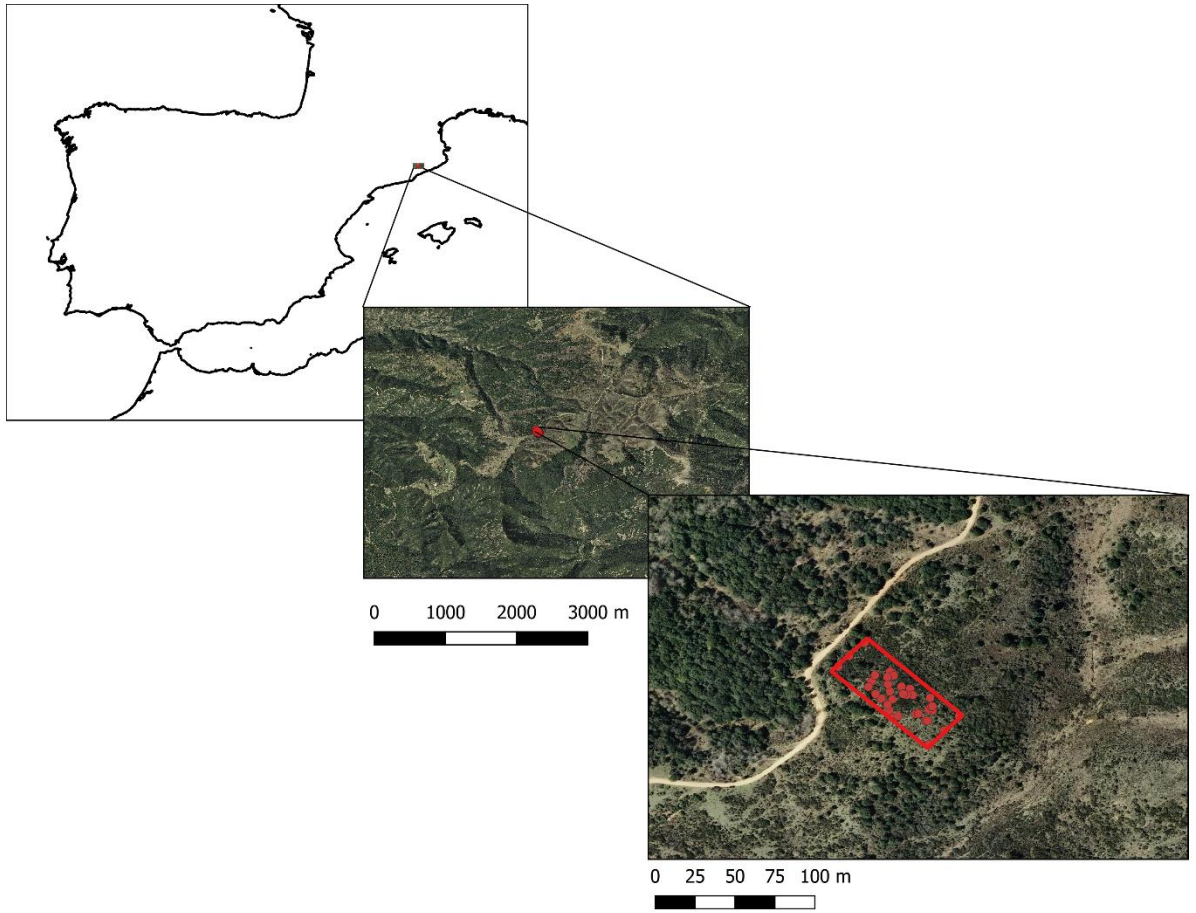
The study was carried out in Pla de la LLacuna in Pla de la Calma, an elevated plateau (1250-1350 m asl) in Montseny Natural Park. The soil is siliceous, with low pH and a significant content in organic C and N. The study site was divided into three plots depending on the slope that it presented. After that, a sampling was carried out regarding the predominant species in the vegetation patch. Those patches were *Calluna, Cladonia, Cytisus, Erica* and *Pteridium*.
After the first samples were taken a low-intensity fire was made and we took samples in the same points 3 months after the prescribed burning. Then several soil variables were analyzed.



Materials and Methods: Variables

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Variable	Type of Variable	Description
Time of the Sampling	Independent	Time when the sampling was carried out (Preburning or Postburning)
Vegetation patch	Independent	Vegetation patch prior to the burning
Slope	Independent	Qualitative Slope of the Sampling Point
SWC5	Dependent	Soil Water Content at the 0 to 5 cm soil depth layer (%)
SWC10	Dependent	Soil Water Content at the 5 to 10 cm soil depth layer (%)
BD5	Dependent	Bulk Density at the 0 to 5 cm soil depth layer (g/cm^3)
BD10	Dependent	Bulk Density at the 5 to 10 cm soil depth layer (g/cm3)
pH_5	Dependent	pH at the 0 to 5 cm soil depth layer
pH_10	Dependent	pH at the 5 to 10 cm soil depth layer
Total N	Dependent	Total Nitrogen at the 0 to 5 cm soil depth layer (g/100g)
Total C	Dependent	Total Carbon at the 0 to 5 cm soil depth layer (g/100g)
P Olsen	Dependent	Phosphorus Olsen at the 0 to 5 cm soil depth layer (mg/kg)
$NO_3^- + NO_2^-$	Dependent	Nitrate and Nitrite at the 0 to 5 cm soil depth layer (ppm)
NH_4^+	Dependent	Ammonium at the 0 to 5 cm soil depth layer (ppm)
P_2O_5	Dependent	Phosphorus pentoxide at the 0 to 5 cm soil depth layer (mg/Kg)

Materials and methods: Statistical Analysis

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Two different approaches were used to analyse the data, a multivariant analysis using Canoco 5.2 and fitting linear mixed models for each variable. All the linear mixed models analyses were carried out with the software R ver. 3.6.3 (R Core Team, 2020)

Models were selected by the Akaike Information Criteria (AIC)

Results: Effect of the low intensity fire

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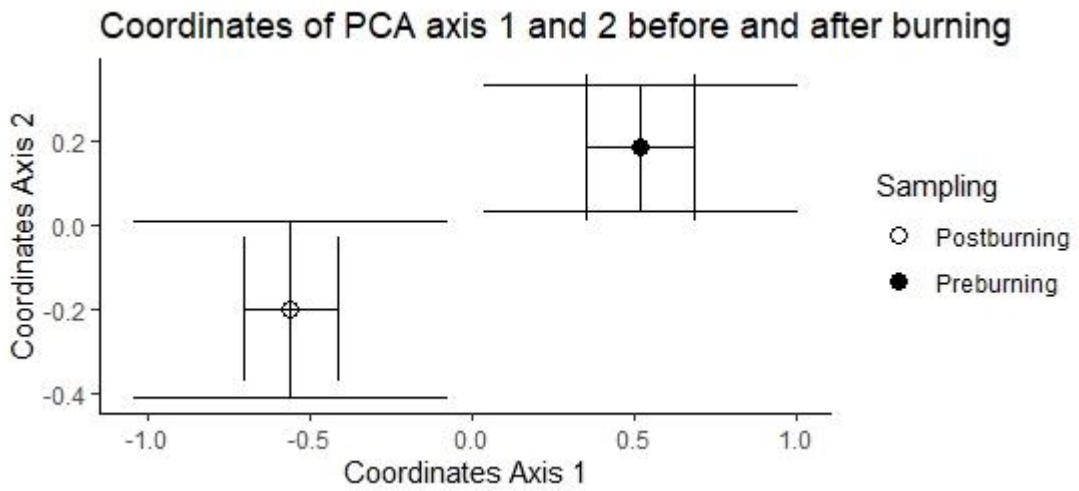

Variable	Description	Effect of the Fire
SWC5	Soil Water Content at the 0 to 5 cm soil depth layer (%)	SWC decreases
SWC10	Soil Water Content at the 5 to 10 cm soil depth layer (%)	No significant differences
BD5	Bulk Density at the 0 to 5 cm soil depth layer (g/cm^3)	BD decreases
BD10	Bulk Density at the 5 to 10 cm soil depth layer (g/cm3)	BD decreases
pH_5	pH at the 0 to 5 cm soil depth layer	pH decreases
pH_10	pH at the 5 to 10 cm soil depth layer	pH decreases
Total N	Total Nitrogen at the 0 to 5 cm soil depth layer (g/100g)	N decreases
Total C	Total Carbon at the 0 to 5 cm soil depth layer (g/100g)	C decreases
P Olsen	Phosphorus Olsen at the 0 to 5 cm soil depth layer (mg/kg)	P Olsen decreases
$NO_3^- + NO_2^-$	Nitrate and Nitrite at the 0 to 5 cm soil depth layer (ppm)	$NO_3^- + NO_2^-$ increases
NH_4^+	Ammonium at the 0 to 5 cm soil depth layer (ppm)	NH_4^+ increases
P_2O_5	Phosphorus pentoxide at the 0 to 5 cm soil depth layer (mg/Kg)	P_2O_5 decreases

Results: Legacy effects of the previous vegetation patch

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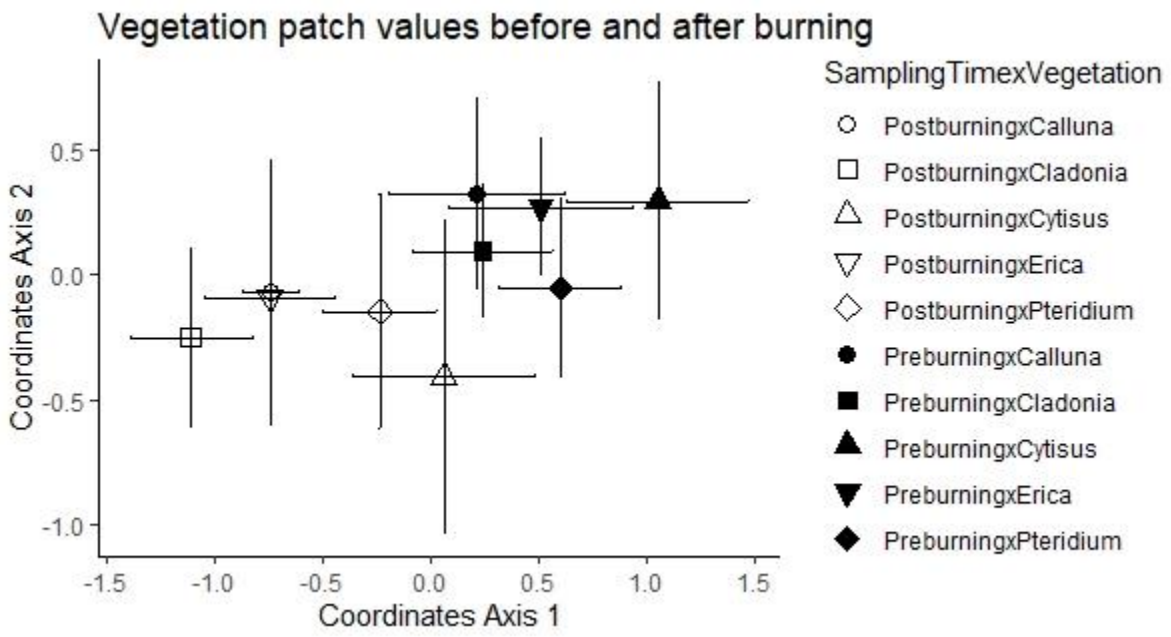

Results: Legacy effects of the previous vegetation patch. Model selection

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Variable	Description	Best model
SWC5	Soil Water Content at the 0 to 5 cm soil depth layer (%)	Interaction between the time of the sampling and the vegetation patch
SWC10	Soil Water Content at the 5 to 10 cm soil depth layer (%)	Interaction between the time of the sampling and the vegetation patch
BD5	Bulk Density at the 0 to 5 cm soil depth layer (g/cm^3)	The previous vegetation patch has no effect
BD10	Bulk Density at the 5 to 10 cm soil depth layer (g/cm3)	The previous vegetation patch has no effect
pH_5	pH at the 0 to 5 cm soil depth layer	The previous vegetation patch has no effect
pH_10	pH at the 5 to 10 cm soil depth layer	The previous vegetation patch has no effect
Total N	Total Nitrogen at the 0 to 5 cm soil depth layer (g/100g)	The previous vegetation patch has no effect
Total C	Total Carbon at the 0 to 5 cm soil depth layer (g/100g)	Interaction between the time of the sampling and the vegetation patch
P Olsen	Phosphorus Olsen at the 0 to 5 cm soil depth layer (mg/kg)	Interaction between the time of the sampling and the vegetation patch
$NO_3^- + NO_2^-$	Nitrate and Nitrite at the 0 to 5 cm soil depth layer (ppm)	The previous vegetation patch has no effect
NH_4^+	Ammonium at the 0 to 5 cm soil depth layer (ppm)	Interaction between the time of the sampling and the vegetation patch
P_2O_5	Phosphorus pentoxide at the 0 to 5 cm soil depth layer (mg/Kg)	Interaction between the time of the sampling and the vegetation patch

Results: Legacy effects of the previous vegetation patch. Difference of means per vegetation patch

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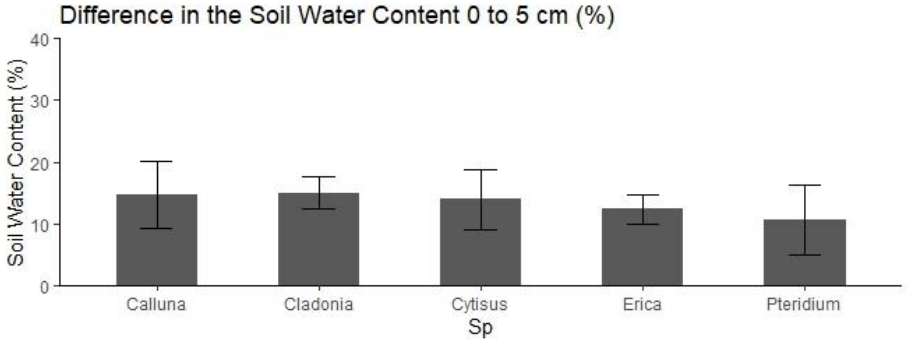
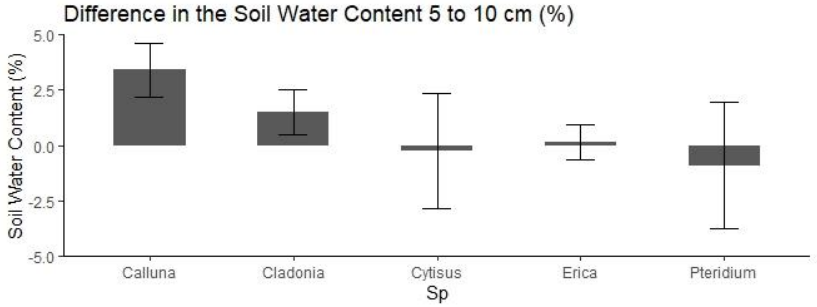
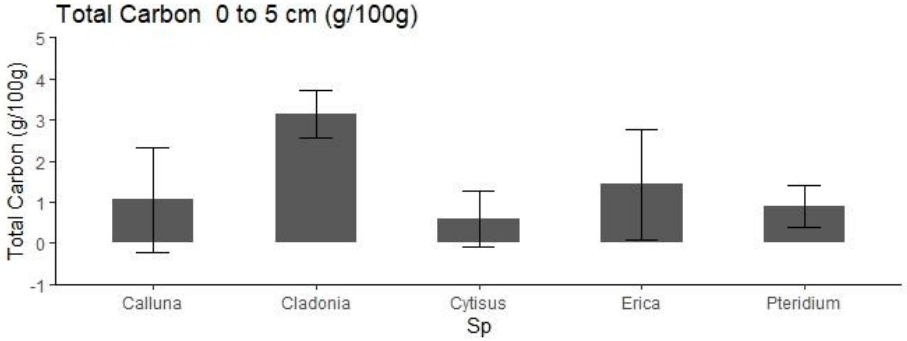
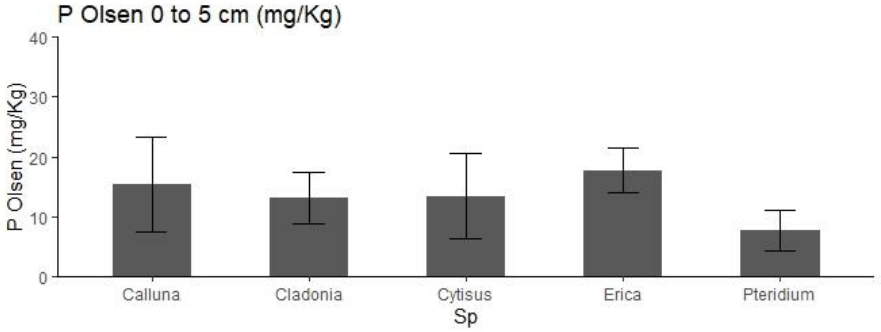
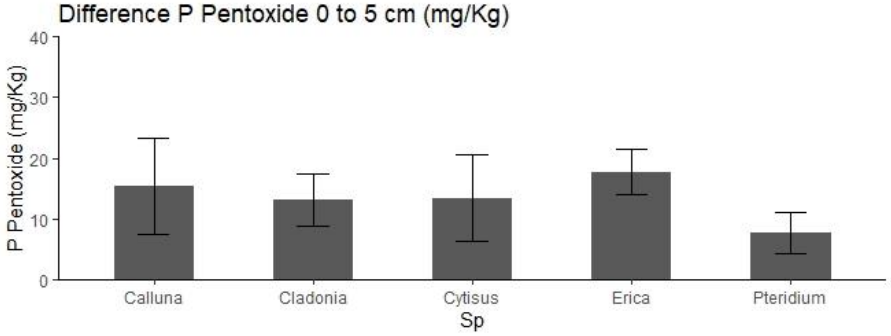
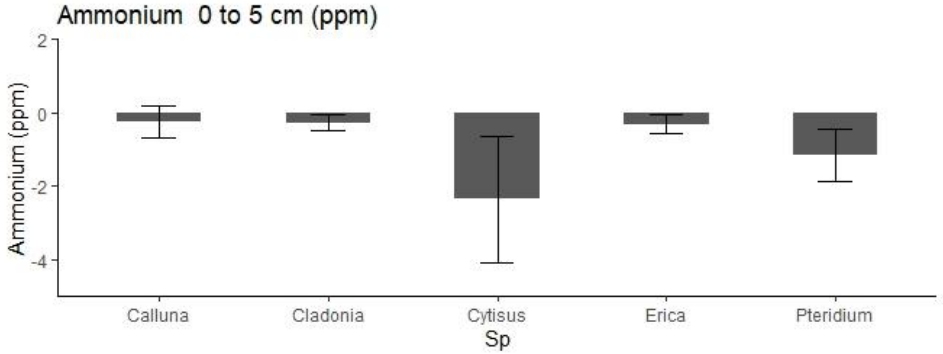




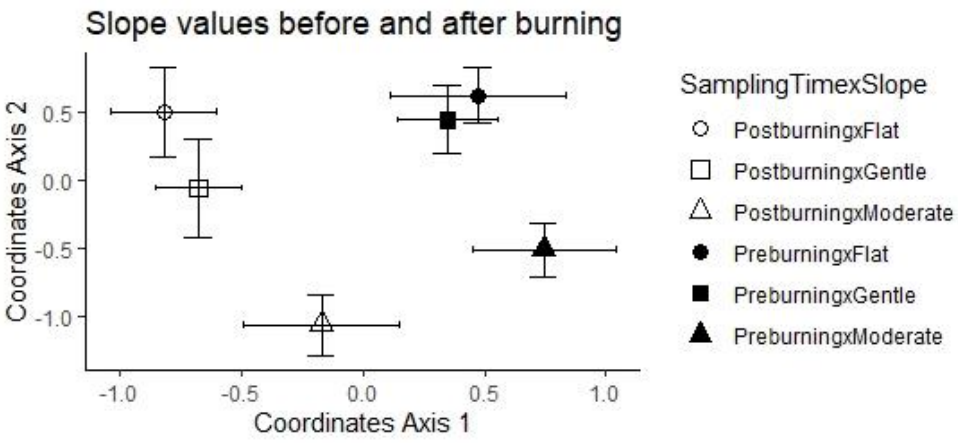








Results. Effect of the topography



Variable	Description	Best model
SWC5	Soil Water Content at the 0 to 5 cm soil depth layer (%)	Model without the vegetation patch (Fire x Slope)
SWC10	Soil Water Content at the 5 to 10 cm soil depth layer (%)	Model without the effect of the fire
BD5	Bulk Density at the 0 to 5 cm soil depth layer (g/cm^3)	Triple interaction model (Fire x Vegetation Patch x Slope)
BD10	Bulk Density at the 5 to 10 cm soil depth layer (g/cm3)	Model without the vegetation patch (Fire x Slope)
pH_5	pH at the 0 to 5 cm soil depth layer	Model without the vegetation patch (Fire x Slope)
pH_10	pH at the 5 to 10 cm soil depth layer	Model without the vegetation patch (Fire x Slope)
Total N	Total Nitrogen at the 0 to 5 cm soil depth layer (g/100g)	Model with the 3 variables (no interactions)
Total C	Total Carbon at the 0 to 5 cm soil depth layer (g/100g)	Model with the 3 variables (no interactions)
P Olsen	Phosphorus Olsen at the 0 to 5 cm soil depth layer (mg/kg)	Model without the vegetation patch (Fire x Slope)
$NO_3^- + NO_2^-$	Nitrate and Nitrite at the 0 to 5 cm soil depth layer (ppm)	Model without the vegetation patch (Fire x Slope)
NH_4^+	Ammonium at the 0 to 5 cm soil depth layer (ppm)	Triple interaction model (Fire x Vegetation Patch x Slope)
P_2O_5	Phosphorus pentoxide at the 0 to 5 cm soil depth layer (mg/Kg)	Model without the vegetation patch (Fire x Slope)