Savage logging effect on soil properties in a fire-affected Mediterranean forest: a two years monitoring research

Jorge Mataix-Solera[1], Jorge Moltó[1], Vicky Arcenegui[1], Fuensanta García-Orenes[1], Katarína Chrenková[2], Pilar Torres[3], A.B. Jara-Navarro[1], Gisela Díaz[3], Ezequiel Izquierdo[1]

(1) GEA, Department of Agrochemistry and Environment, University Miguel Hernández. Avda. Universitat, s/n, 03202, Elche, Alicante, Spain
(2) Department of Soil Science, Faculty of Natural Science, Comenius University, Mlynská dolina B-2, 842 15 Bratislava, Slovak Republic (katka.chrenkova@gmail.com)
(3) Department of Applied Biology, University Miguel Hernández. Avda. Universitat, s/n, 03202, Elche, Alicante, Spain

Introduction

In the Mediterranean countries, forest fires are common and must be considered as an ecological factor, but changes in land use, especially in the last five decades have provoked a modification in their natural regime. Moreover, post-fire management can have an additional impact on the ecosystem; in some cases, even more severe than the fire. Salvage logging is a traditional management in most fire-affected areas. In some cases, the way of doing it, using heavy machinery, and the vulnerability of soils to erosion and degradation make this management potentially very aggressive to soil, and therefore to the ecosystem. Very little research has been done to study how this treatment could affect soil health. In this research we show 2 years of monitoring of some soil properties in an area affected by a forest fire, where some months later this treatment was applied.

Materials and Methods

The study area is located in "Sierra de Mariola Natural Park" in Alcoi, Alicante (E Spain). A big forest fire (>500 has) occurred in July 2012. The forest is composed mainly of *Pinus halepensis* trees with an understory of typical Mediterranean shrubs species such *as Quercus coccifera, Rosmarinus officinalys, Thymus vulgaris, Brachypodium retusum*, etc. Soil is classified as a Typic Xerorthent (Soil Survey Staff, 2014) developed over marls. In February 2013, salvage logging (SL) treatment consisting in a complete extraction of the burned wood using heavy machinery was applied in a part of the affected forest. Plots for monitoring this effect were installed in this area and in a similar nearby area where no treatment was done, and then used as control (C) for comparison. Soil samplings were done immediately after treatment and every 6 months during two years. Some soil properties were analysed, including soil organic matter (SOM) content, basal soil respiration (BSR), microbial biomass carbon (MBC), bulk density (BD), soil water repellency (SWR), aggregate stability (AS), field capacity, nitrogen and available phosphorous.

In all the soil samples taken have been analyzed :

- Bulk density (BD)
- Water holding capacity (WHC)
- Aggregate staility (AS)
- Soil organic matter (SOM)
- Microbial biomass carbon (MBC)
- Basal Soil Respiration (BSR)
- Available Phosphorous content (P)
- Nitrogen content (N)

Results and Discussion

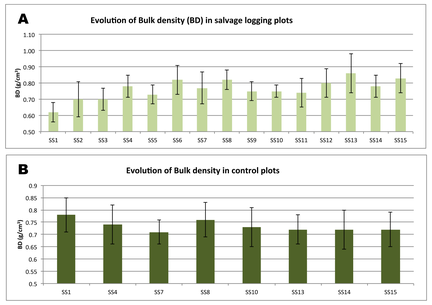

Figure 1. Evolution of Bulk density in salvage logging plots (A) and control plots (B) Mean values and standard deviation.

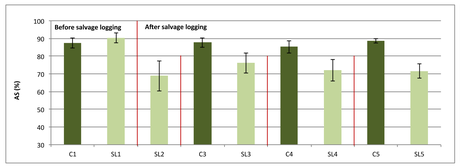

Figure 2. Evolution of aggregate stability (AS) in salvage logging plots versus control plots. Mean values and standard deviation.

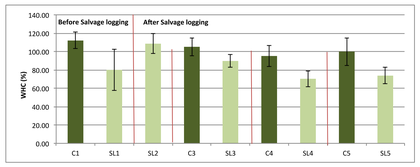

Figure 3. Evolution water holding capacity (WHC) in salvage logging plots versus control plots. Mean values and standard deviation.

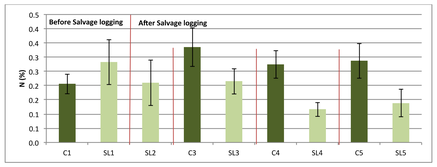

Figure 4. Evolution nitrogen content (N) in salvage logging plots versus control plots. Mean values and standard deviation.

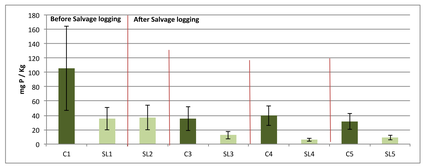

Figure 5. Evolution of available phosphorous (P) in salvage logging plots versus control plots. Mean values and standard deviation.

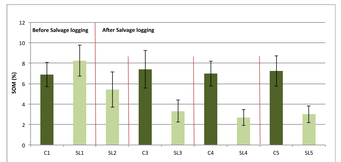

Figure 6. Evolution of organic matter content (OM) in salvage logging plots versus control plots. Mean values and standard deviation.

Soil Samplings dates:

- C1 and SL1: 1/02/2013. Day of application of Salvage logging treatments
- SL2: 12/03/2013
- C3 and SL3: 101/09/2013
- C4 and SL4: 16/05/2014
- C5 and SL5: 23/10/2014

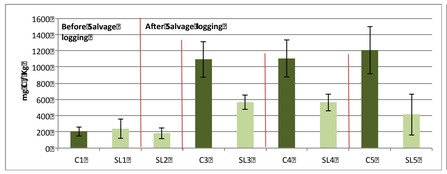

Figure 7. Evolution of Microbial biomass carbon (MBC) in salvage logging plots versus control plots. Mean values and standard deviation.

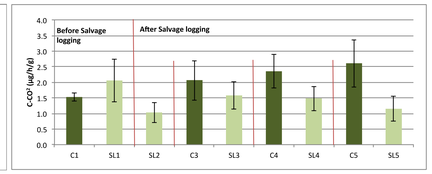

Figure 8. Evolution of basal soil respiration (BSR) in salvage logging plots versus control plots. Mean values and standard deviation.

The figure 1 show the evolution of bulk density in the plots where all the burned wood was extracted (A) versus control plots (B). While in control area there are not significant variations for this parameter, in the salvage logging area, the bulk density increased with time especially in first months showing a compaction of the soil by this management.

In general all the soil parameters studied in this work have been affected by the post-fire treatment. The aggregate stability was significant modified by the salvage logging treatment, as we can be observed in the figure 2, the % of AS at the beginning of the experiment after fire was very high closely to 90%, and however one month after post-fire treatment this value decreased a 20% in these plots (SL). The AS increased with the time but never reached the initial value that it was kept in control area during all studied period. WHC (figure 3) shows slightly low values in the salvage logging area than in the control area. The available phosphorous content decreases in the soil with salvage logging treatment, as a consequence of the loss of ash due to increase of erosion suffered in this area. In a similar way the content of nitrogen in the soils with post-fire treatment showed a decrease of this nutrient with time, while the control soils almost kept the same level of nitrogen during the experiment (figures 4 and 5)

As we can see in figure 6, the content of soil organic matter in salvage logging area showed an significant progressive decrease during the study period, reaching values of half of the initial content in the last soil sampling. This loss of organic matter indirectly affects to other soil properties and as consequence a loss of soil quality in the salvage logging treatment area occurred. The control area didn´t show significant variations for this parameter, keeping the content of organic matter in the soil.

One of the most directly affected parameters by the fire is the microbial biomass carbon. In figure 7 can be observed the low values registered in all the experimental plots in first soil sampling. However, with time the control area showed a good recovery of microbial populations after the third sampling that is quite slower in the salvage logging area. This parameter responds very quickly soil perturbations. Here is also indicating the negative effect of this post-fire treatment. A similar behaviour has been observed in basal soil respiration (figure 8) with a lower microbial activity immediately after fire. The soil of control area was going recovered the microbial activity in the following samplings while the area with post-fire salvage logging treatment almost did not show an increase of this activity.

CONCLUSIONS

After two years of research, results showed significant soil degradation as a consequence of the salvage logging treatment. Most of the soil parameters studied showed differences between control and salvage logging treatments, SOM content in first 2.5 cm of topsoil being less than half in SL plots in comparison with C plots. BSR, MBC and AS were also significant lower in SL plots. BD increased as a consequence of SL treatment. In conclusion, we can affirm that with this type of soil, which is very vulnerable to soil degradation, this treatment has a very negative effect on the ecosystem, this was also reflected in the abundance and diversity of plant species.

***Acknowledgements**: to the "Ministerio de Economía and Competitividad" of Spanish Government for finance the POSTFIRE project (CGL2013- 47862-C2-1-R), Alcoi council, ACIF Alcoi, and Sierra de Mariola Natural Park for their collaboration.*

EGU 2015. European Geosciences Union. General Assembly 2015. Vienna Austria. 12-17 April 2015