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The impact of recurrent wildfire on chemical properties of forest soils under pine from central Spain

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Many soils at Mediterranean regions are subjected to progressive degradation. In the last century, the effect of fire was a major constraint in the evolution of most areas reforested with pine, leading to severe changes in soil properties, their variable intensity depending both on fire severity and fire recurrence patterns. In particular it is of special interest the quantitative assessment of the intensity of fire on soil to establish the levels from which irreversible ecosystem change occurs, which would make necessary the application of invasive soil rehabilitation practices. The data from the present study were obtained from twelve conifer forest soils at Sierra de Gredos (Ávila, central Spain) twenty years after two repeated fires along two years. The data matrix, consisting of a series of key soil variables (soil abiotic factors, humic substances and soil biological activity determined in comparable laboratory constraints) was processed with a series of linear and non-linear multivariate data treatments with a dual purpose: i) quantifying the extent of the fires' effects (comparison of distances between undisturbed and burned soils in the plane obtained after multidimensional scaling) and ii) identifying those descriptors responsive to the impact of fire, by using factorial treatments such as discriminant analysis with backward variable selection. It was noted that the fire-induced changes in some soil properties were more or less permanent in the long term. Soil colour analysis (digital analysis of images yielding hue, saturation and brightness components) then was considered the primary source of indices for the concentration of black carbon in soil. Conversely, a set of soil characteristics indicated

the extent to which the spontaneous recovery of the soil is produced as a result of vegetation regrowth. Twenty years after repeated fire it was observed a decrease of soil C concentration, whereas other variables such as pH, exchangeable Ca and K were slightly increased with respect to control soil. Chemical fractionation of soil organic matter, in combination with routine characterization of humic acids, with visible and infrared spectroscopy, allowed to postulate a series of functional relationships with soil properties. In particular, the most significant ($P < 0.05$) changes in soil organic matter point to progressive insolubilization and loss of colloidal properties as a consequence of the formation of humic-like fractions representing intermediate stages in the formation of black carbon. In fact, the significant increase in the humic acid-to-fulvic acid ratio (suggesting thermal decarboxylation), and some decrease in the soil cation exchangeable capacity showed evidenced a loss of soil colloidal properties. On the other hand, increased contents of some microelements such as total Mn and of Mn_o (extracted by oxalate) in burnt soils, as well as some decrease of the C-to-N ratio, suggested concentration of stable forms of indispensable macro- and microelements. This could be associated to the increase on soil C mineralization coefficients of most forests, twenty years after wildfire, calculated from the soil respiration curves.

Key words: Recurrent wildfire, soil properties, soil organic matter fractions, humic acid