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Soil quality indicator selection in Chilean volcanic soils formed under temperate and humid conditions

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ABSTRACT

Volcanic soils are extremely productive thanks to their particular characteristics. Therefore, even though they represent < 1% of the soils worldwide, they are very important for global and local agriculture, as they account for > 60% of the arable land of Chile. However, studies evaluating their soil quality are still scarce. Subsequently, soil quality indicators have not yet been established for Chilean volcanic soils. Hence, the aim of this study was to select a set of soil quality indicators to evaluate changes in Chilean volcanic soils, mainly due to land use, but also considering seasonal changes. Thus, three soils derived from volcanic materials were sampled (with different intrinsic properties), on five sampling dates, under three land uses (intensities): native forest (NF), prairie (P) and crops (C). Soil samples were taken to evaluate both chemical (disturbed samples) and physical (undisturbed cylinders and soil blocks) properties. A total of 27 soil properties were measured and/or calculated, among these are: penetration resistance, saturated hydraulic conductivity, air conductivity, bulk density, total porosity pore size distribution, aggregate stability, pH, nutrient contents, Al saturation, effective cation exchange capacity, soil organic carbon and extractable Al. To effectively select the indicators a multivariate analysis (PCA) was performed. The proposed set of indicators for soils derived from volcanic materials include: i) bulk density, ii) plant available water pores in volcanic soils, iii) wide coarse pores, iv) air conductivity at 6 kPa, v) soil organic carbon, vi) extractable Al with ammonium acetate, vii) pH in water, viii) P-Olsen and ix) base sum. Main difference in soil quality indicators chosen in this study, compared to previous studies of this type, was the inclusion of extractable Al with ammonium acetate indicator, which is strongly related to the inherent soil properties of these volcanic soils.

1. Introduction

Researchers around the world have been making significant efforts to assess soil quality and management practices in order to minimize the negative impacts caused by soil mismanagement. Nonetheless, there is still a serious lack of studies of this type regarding Andisols. Although these soils represent a small portion of the world's soils (< 1%), they are highly productive and form unique ecosystems throughout the world (USDA-NRCS, 2010). In Chile, soils derived from volcanic materials have great importance since they account for 50–60% of this country's arable land, and much of the cereal, livestock and forestry production are carried out in these soils (Besoain, 1985; Bertrand and Fagel, 2008).

Studies evaluating changes in soil properties and their productivity as a result of management and use have been conducted in Chilean soils derived from volcanic materials (Ellis et al., 1982, 1985, 1993a, 1993b; Ellis, 1995; Pinochet et al., 2000; Zagal et al., 2002; Cuevas et al., 2004; Alvear et al., 2005; Zagal and Córdova, 2005; Dörner et al., 2009a, 2009b, 2010). Nevertheless, a broad outlook and specific soil quality indicators have not yet been established to evaluate the soil quality of these particular soils.

Evaluating changes in soil quality must use appropriate indicators that reflect the soil's capacity to function (Larson and Pierce, 1994; Doran and Parkin, 1994; Karlen et al., 1997), considering the effects of natural and human disturbances in a way that facilitates the identification of sustainable land management practices (Doran and Parkin, 1994; Sims et al., 1997; Schipper and Sparling, 2000). For these purposes, soil quality indicators must be sensitive to management and climate and be able to integrate biological, physical and chemical processes (Doran and Parkin, 1994). Carter (2002) affirms that current approaches used to assess soil quality are based on the following sequence: i) purposes, ii) functions, iii) processes, iv) properties or

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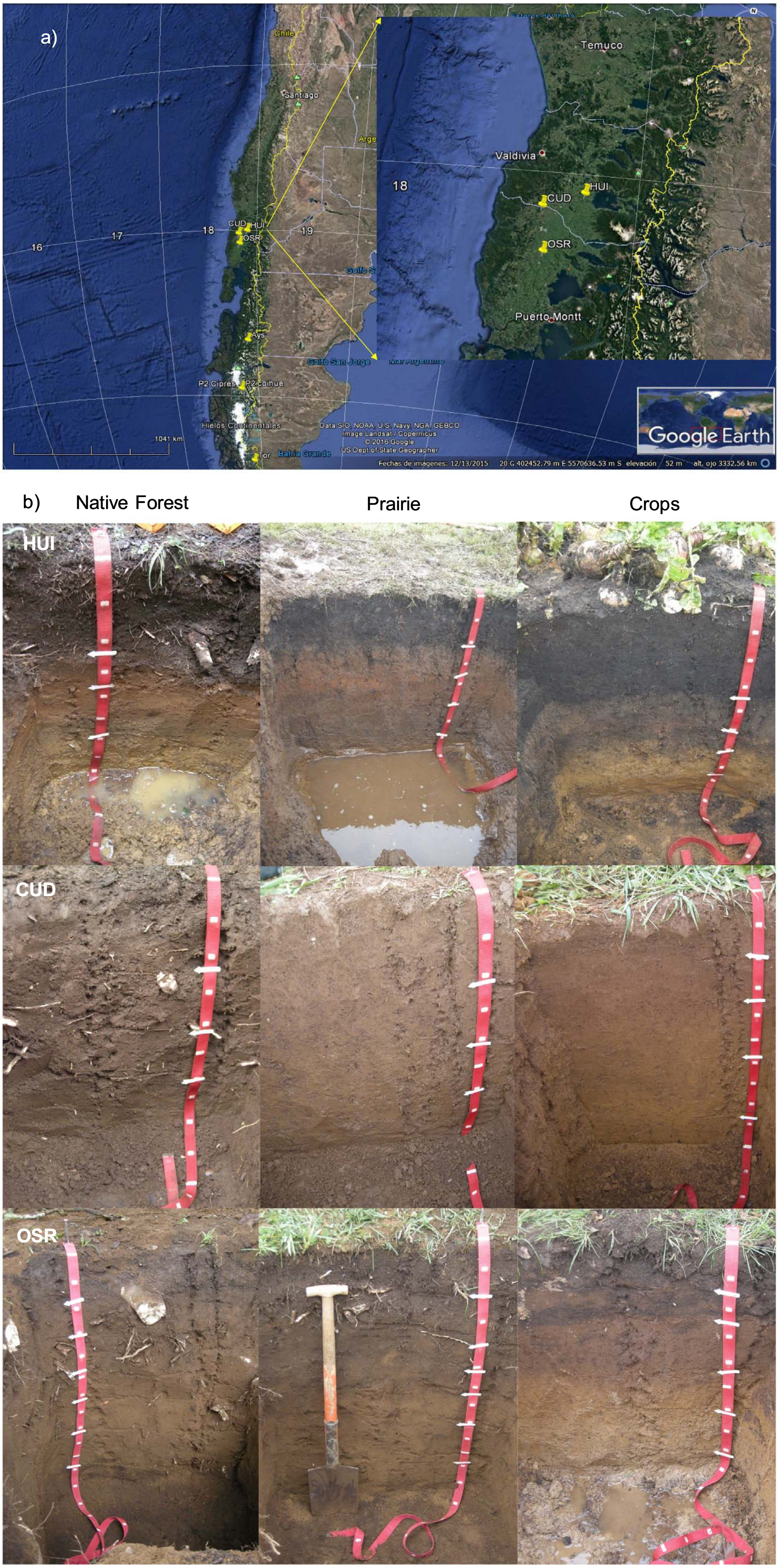

Fig. 1. a) Location of soil sampling sites: HUI, Huiti; CUD, Cudico and OSR, Osorno (image from Google Earth). b) Pictures of the evaluated soil profiles for each soil and land use.