Supplementary information

Early Response of Soil Properties Under Different Restoration Strategies in Tropical Hotspot

Katarzyna A. Koryś[1,2], Agnieszka E. Latawiec[1,2,3,4], Maiara S. Mendes[1,2,5], Jerônimo B. B. Sansevero[6], Aline F. Rodrigues[1,2], Alvaro S. Iribarrem[1,2], Viviane Dib[1,2,7], Catarina C. Jakovac[8], Adriana Allek[2,7], Ingrid Pena[1,2], Eric Lino[1,2], Bernardo B. N. Strassburg[1,2,7]

[1] International Institute for Sustainability, R. Dona Castorina 124, 22460-320, Rio de Janeiro Brazil.
[2] Rio Conservation and Sustainability Science Centre, Department of Geography and the Environment, Pontifical Catholic University of Rio de Janeiro, R. Marquês de São Vicente, 225 - Gávea, Rio de Janeiro - RJ, 22451-000, Brazil.
[3] University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, UK. Switchboard: +44(0) 1603 456161.
[4] Departament of Production Engineering, Logistic and Applied Computer Sciences, University of Agriculture in Kraków, Balicka 116B, Kraków 30-149, Poland.
[5] Escola Nacional de Botânica Tropical (ENBT), Rua Pacheco Leão, 20-40-Solar da Imperatriz, Horto, 22460-036, Rio de Janeiro.
[6] Departament of Environmental Science, Federal Rural University of Rio de Janeiro (UFRRJ), Rodovia BR 465, km 07, 23890-000, Seropédica, Rio de Janeiro, Brazil, ORCHID 0000-0002-3389258.
[7] Programa de Pós Graduação em Ecologia, Federal University of Rio de Janeiro, 68020, Rio de Janeiro, Brazil.
[8] Forest Ecology and Management Group, Wageningen University, 6700 AA Wageningen, The Netherlands.

1. Description of the soil sampling

Table S1 Mean values and ± SD of soil properties (0-20 cm) of each restored area in Fazenda Dourada, Brazil - description:

First column of Table S1: "identification" informs about the study site. For example, P1_active/slope refers to soil samples collected on site of active planting no 1, implemented on the slop. Second column "sample ID" describes the soil samples. On each restored site three blocks (B) were established (twelve in total). Each block was divided into nine parcels of 10 x 10 m (P) totalling of twenty-seven parcels per restored area ("treatment"). From each parcel, ten soil samples were collected at depth of 0-20 cm, mixed into the composed sample and stored in labelled bag with the sample ID. Blocks were established and marked as follows: B1, B2, B3 on site P1 of active planting/slop; B4, B5, B6 on site P2 of active planting/slope; B7, B8, B9 on site P3 of active planting on flat area; and B10, B11, B12 on the area where natural regeneration (REG) occurred. Therefore, B1P1 refers to a "composed sample of ten soil samples, collected from block 1, parcel no1, site P1 of active planting on the slope" Soil samples were preserved and shipped for further analysis to the Soil Analysis Laboratory at Federal University of Lavras (Brazil). The following columns in table S1 contain soil parameters with their respective units, and the analytical results of laboratory analysis. Mean values and standard deviations were

calculated for selected soil properties. For P1, P2 and P3 n= 270 and for REG n =260, as one sample had been damaged during shipment.

Table S2 Mean values and ± SD (n =10) of soil properties (0-20 cm) from pasture/reference system (control) in Fazenda Dourada, Brazil – description:

First column of Table S2: "identification" informs about the study site ("CONTROL"). Second column "sample ID" refers to the soil sample identification. Ten soil samples were collected randomly at depth of 0-20 cm from unproductive pasture (P). Each sample was stored in labelled back with the sample ID and shipped for further analysis to the Soil Analysis Laboratory at Federal University of Lavras (Brazil). The following columns in table S2 contain soil parameters with their respective units, and the analytical results of laboratory analysis. Mean values and standard deviations were calculated for selected soil properties (n =10).

Table S3 Means values and ± SD of C:N ratio (0-20 cm) of each restored area and pasture/reference system (control) in Fazenda Dourada, Brazil. P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration; CON: pasture. All results showed no significant difference ($p<0.05$) – description:

C: N ratio was calculated with the SOM and N values. The SOM values were converted to SOC using the conversion factor 0.58.

Table S4 List of the plant species in sites of active restoration (P1, P2, P3) and natural regeneration (REG) in Fazenda Dourada, Brazil.

For more informations, see: Galvão G. 2016 *Estrutura da vegetação, composição florística e riqueza de espécies de diferentes modelos de restauração ecológica na Mata Atlântica.* Universidade Federal Rural do Rio de Janeiro, Seropédica, RJ; 2016.
Bachelor thesis. Available from: http://repositorio.im.ufrrj.br:8080/jspui/handle/1235813/3110 (in Portuguese only).

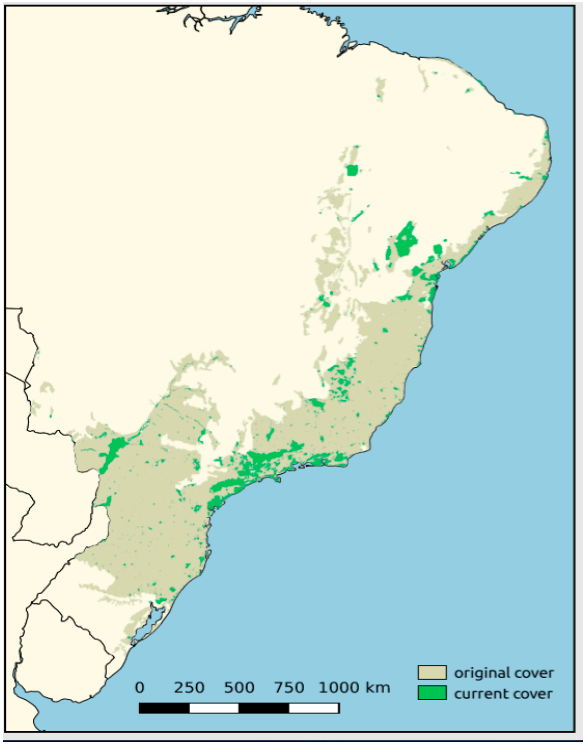

Figure S1. Map of Brazilian Atlantic Forest (original and current vegetation cover). Source: International Institute for Sustainability.

2. The quadratic propagation of standard deviations method description:

We compute how the uncertainties in our measurements are propagated to our results assuming they are all random, and uncorrelated. Specifically, we want to compute the associated uncertainty for any of the quantities Q provided in this work, measured against a reference value. We take a number of repetitions for the measurement of a given quantity Q and obtain the average value for that set of measurements, Qm, and its associated standard deviation, δQm. We repeat the same process, measuring the same quantity Q a number of times in the reference area and getting the average value for that set of reference measurements, Qr, and its standard deviation, δQr. Assuming both distributions are normal, it can be derived (e.g., Ku 1966) that the uncertainty δQv, corresponding to the average variation Qv = Qm – Qr , is given by:

$$\delta Q_v = \sqrt{(\delta Q_m)^2 + (\delta Q_r)^2}$$

We use the result above in two layers of analyses throughout the paper. At first, we take a set of measurements for selected parameters in each area, for instance soil moisture content (SMC) as the Q_m above and obtain its corresponding average variation Q_{vs} with respect to the SMC measured in the reference area. We compute its propagated uncertainty, δQ_{vs}, as above.

Having computed all the average variations and their uncertainties, we want to compare their computed values for two different quantities, say SMC, as before, versus pH. We compute the difference between their average's variations, Q_{vs} and Q_{vp} respectively, simply as $Q_{vs\text{-}p} = Q_{vs} - Q_{vp}$. Assuming the same conditions normality for both distributions and uncorrelation between them, we can apply the same equation above to compute the uncertainty $\delta Q_{vs\text{-}p}$ associated with the difference between the average variations, $Q_{vs\text{-}p}$.

Grafical results for selected soil properties (Na, Fe, Mn, pH, SMC, clay, silt, sand, N, P, K, C:N and SOM) are presented below (figures S2-S9)

References:

Ku, H. H. (October 1966). "Notes on the use of propagation of error formulas". Journal of Research of the National Bureau of Standards. 70C (4): 262

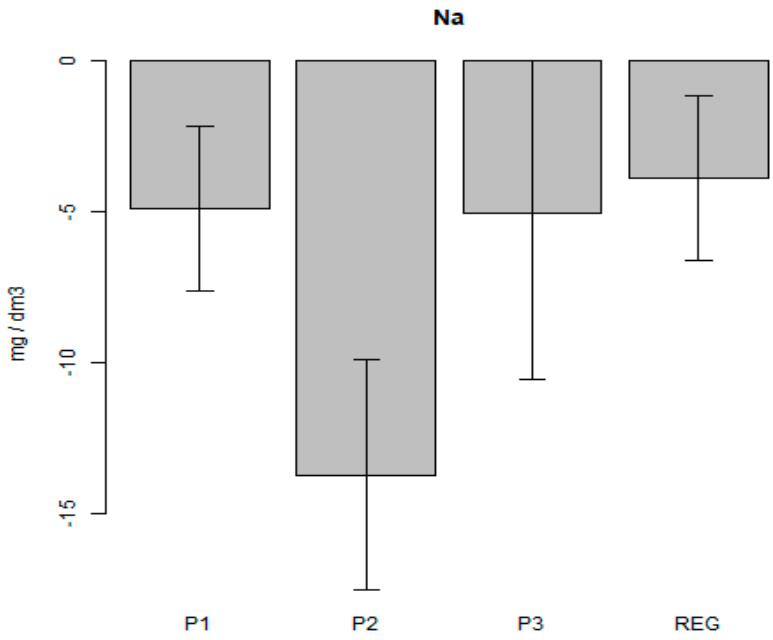

Figure S2. Variation of sodium content (0-20 cm) in each restored area with respect to control (0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

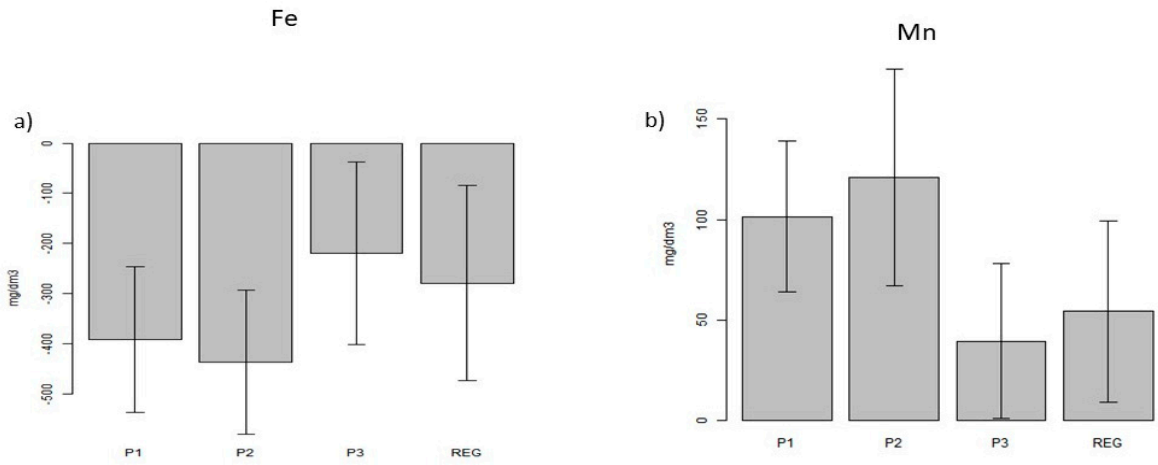

Figure S3. Variation of iron (a) and manganese (b) content (0-20 cm) in each restored area with respect to control (0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

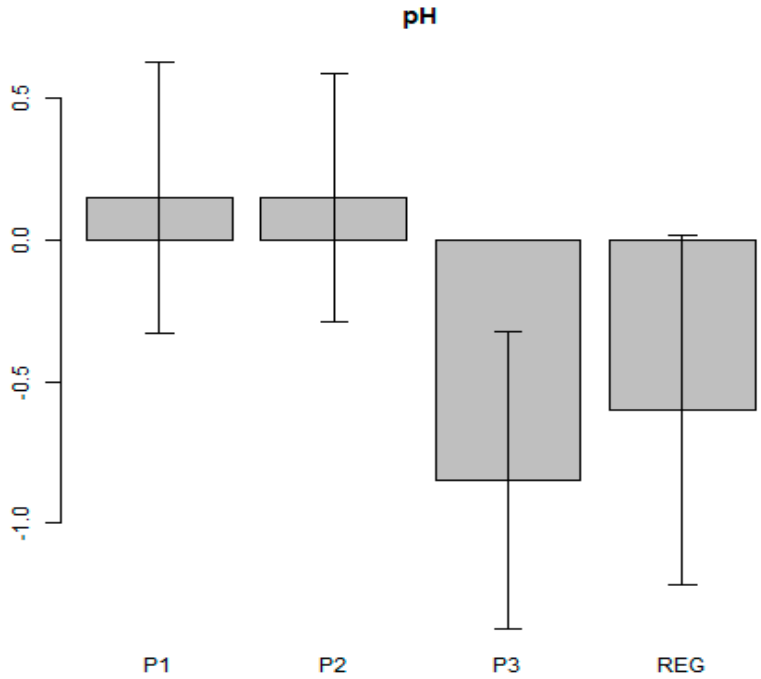

Figure S4. Variation of soil pH (0-20 cm) in each restored area with respect to control (0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

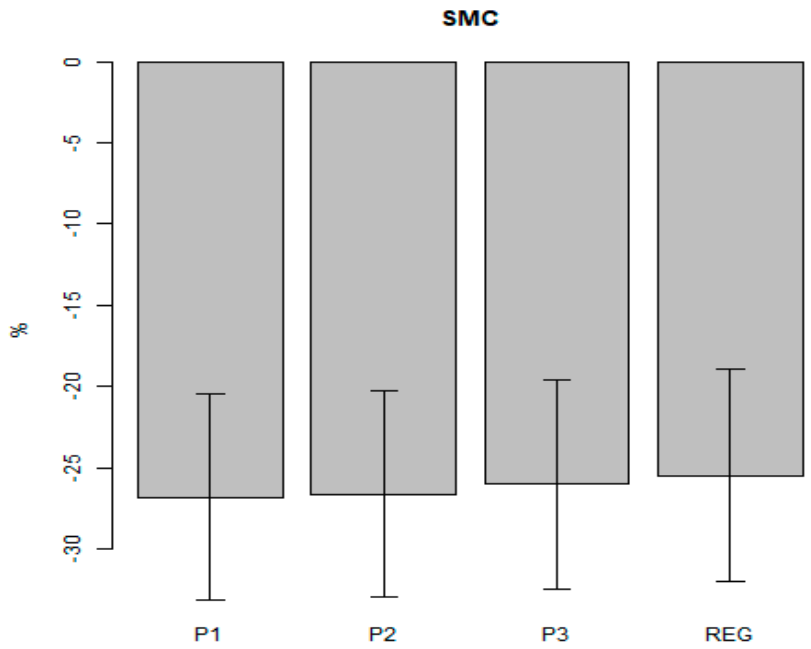

Figure S5. Variation of soil moisture content (0-20 cm) in each restored area with respect to control (0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

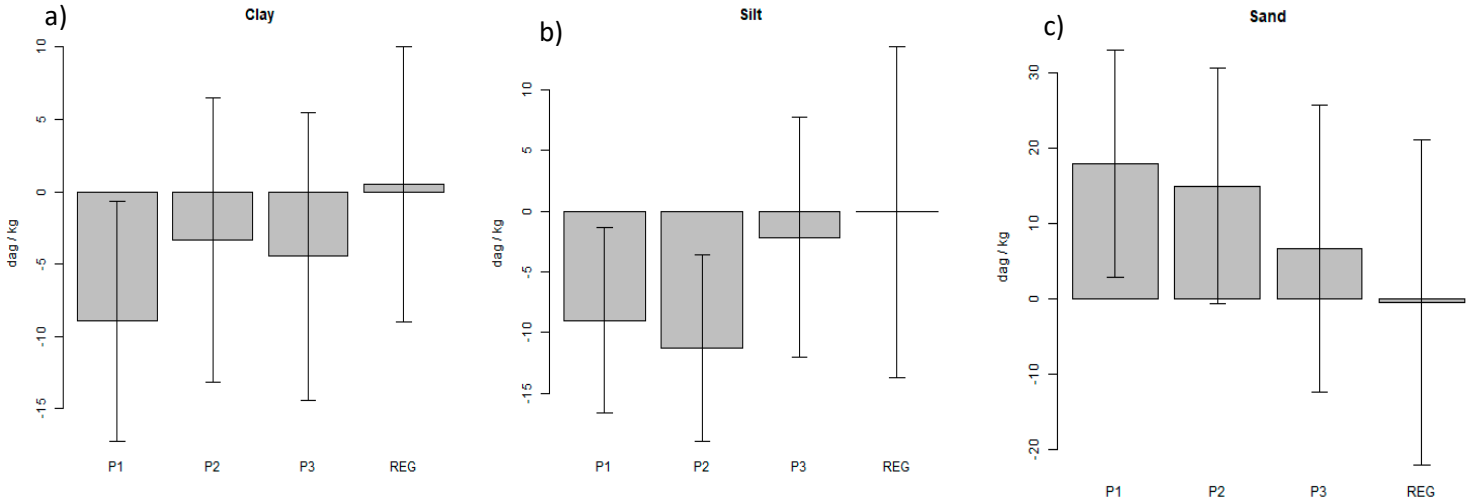

Figure S6. Variation of soil texture (0-20 cm): clay (a), silt (b) and sand (c) in each restored area with respect to control (0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

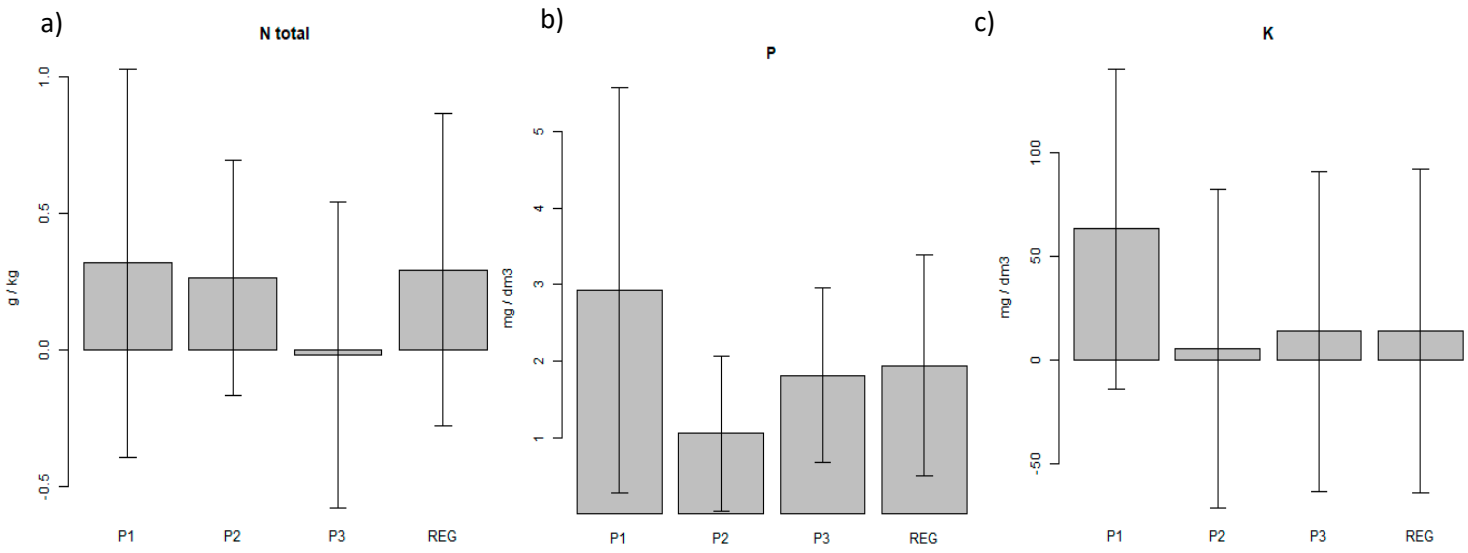

Figure S7. Variation of soil macronutrients (0-20 cm): total nitrogen (a), phosphorus (b) and potassium (c) in each restored area with respect to control *(*0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

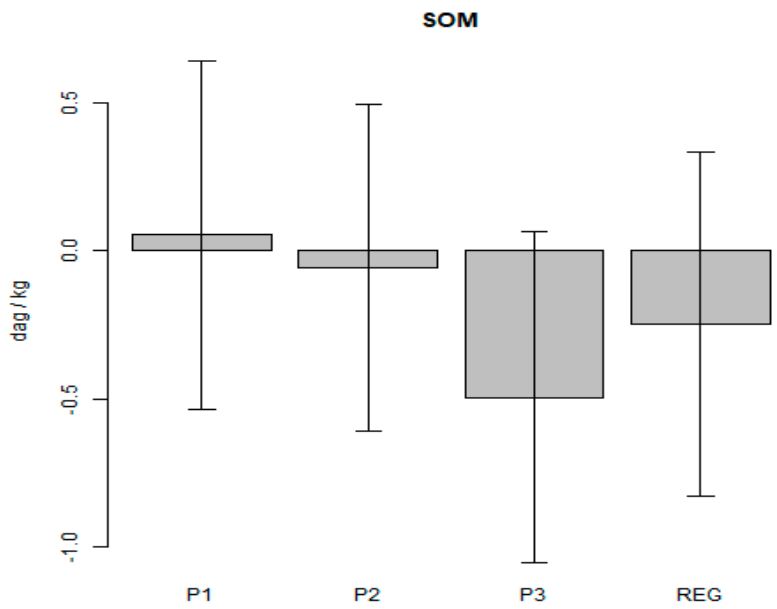

Figure S8. Variation of soil organic matter (0-20 cm) in each restored area with respect to control *(*0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.

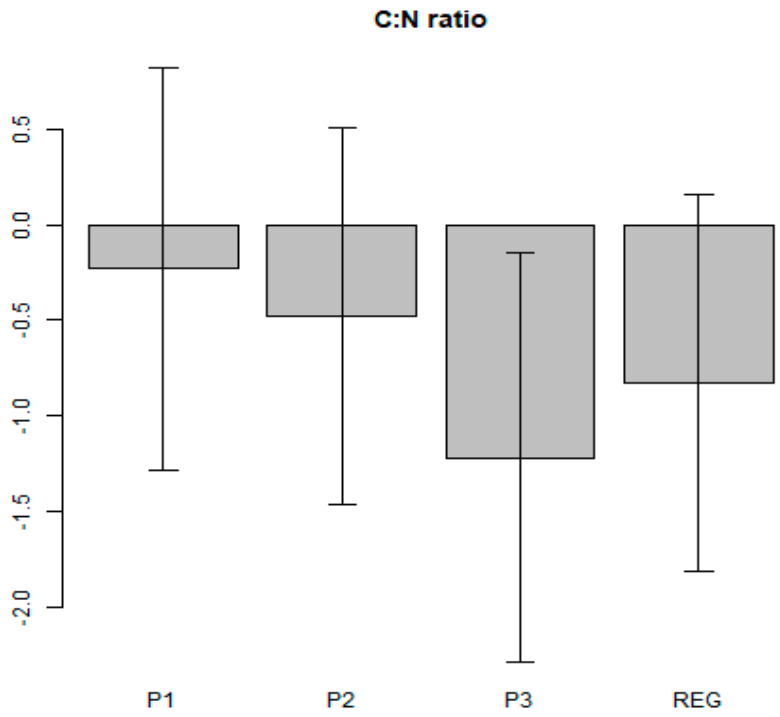

Figure S9. Variation of C:N ratio in soil (0-20 cm) in each restored area with respect to control (0 value on axel x). P1: active/slop; P2: active/slop; P3: active/flat; REG: natural regeneration. Error bars represent the standard deviation of the differences.