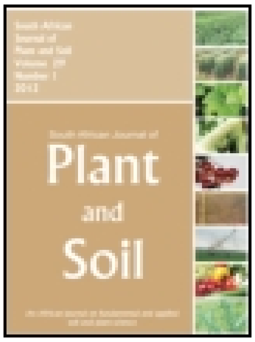

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Soil organic carbon stocks and properties are affected by plant cover types in an urban ecosystem in Colombia

Víctor Mondragón [1,2], Flavio Moreno Hurtado [1] and Daniel Francisco Jaramillo Jaramillo [1]

[1]*Universidad Nacional de Colombia Sede Medellín*
[2]*Fundación Universitaria de Popayán, Ecología*
**Correspondence: vamondragonv@unal.edu.co*

Soil organic carbon (SOC) is the main element in soil organic matter (SOM) and its storage or release into the atmosphere is sensitive to changes in land use. This study evaluated SOC storage and SOM quality in the Metropolitan Regional Natural Park, Cerro El Volador, Medellín-Colombia, in areas where plant cover was restored with plants from different functional groups consisting of secondary vegetation (SV), forest plantations of *Eucalyptus globulus* Labill. (EUC) and *Pinus patula* Schltdl. & Cham. (PIN), and pastures (PAS). Soil samples were taken at the O horizon and at two soil depths at the A horizon (0–10 and 10–20 cm). The quality of the SOM was evaluated through humification indices, spectrophotometric tests and carbon distribution in humic substances. The highest storage of SOC in the O horizon occurred in PIN, followed by EUC, SV and PAS. In descending order, the vegetation with the highest SOC values for the A horizon at both depths evaluated were EUC, PAS, PIN and SV. Humification indices showed that the SOM was mainly composed of fresh SOM with little humification. The humification process of SOM evolved towards humic acids of the P-group. These results show that the change of cover significantly affects the storage of SOC, the characteristics of SOM and the properties of the soil.

Keywords: humic substances, plant cover, soil organic matter, Ultisols

Introduction

Soils contain approximately 1 550 Gt of organic carbon (C) of the 2 110 Gt of organic C estimated to be present in the terrestrial biosphere (Lal 2004). Its storage or release is sensitive to changes in land use (Ordoñez et al. 2015). Degradation of natural ecosystems contributes to the release of C into the atmosphere from two sources: (1) decomposition and oxidation of biomass above and below soil; (2) oxidation and mineralisation of SOM (Lal et al. 1998). More than two-thirds of the C in the terrestrial biosphere is stored as SOM and although this is not the most abundant component in most soils, it has an enormous influence on the physical, chemical and biological properties of soil. This makes it a key indicator of soil quality in agricultural and environmental terms (Tfaily et al. 2017).

The most important components of SOM are the humic substances (HS). However, there is still disagreement about the origin of these substances. Muscolo et al. (2013) suggested that they are produced by biochemical reactions in the transformation of biological debris; different conditions of vegetation, climate, soil type, and biological activity generate differences in its components: humic acids (HA), fulvic acids (FA) and humins (Watson et al. 2000). Regarding these components, HAs are indicators of SOM quality and contribute to the long-term storage of C in soils and hence, to the mitigation of greenhouse gas emissions (Piccolo 1996). Land uses affect SOM properties and C content in HS, because it affects the microclimatic regimes and the rupture of soil aggregates. These factors in turn affect the degree of humification and oxidation of SOM (Dos Santos et al. 2019). The study of SOM properties, the degree of humification and the C content in its different components is helpful in understanding the processes and mechanisms that influence the stable storage of SOC (Mosquera et al. 2007).

The potential of soils as C sinks has attracted considerable scientific attention in recent years (Soleimani et al. 2019). Reforestation of degraded lands has the potential to store C, mainly as a result of the continuous deposition of plant residues above and below the soil (Six et al. 2004). The SOC in the surface layer under secondary vegetation usually has a high content of labile carbon, which is prone to be lost in the form of CO_2 (Yuan et al. 2018). Changes in tropical soils caused by reforestation with fast-growing trees of the genus *Pinus* and *Eucalyptus* are not yet fully understood and literature often reveals conflicting conclusions about the processes occurring and their effects, especially on the dynamics and properties of SOC (Zinn et al. 2002).

The objective of this study was to evaluate the SOC storage and SOM quality in areas where vegetation cover was restored with plants of different functional groups, these being secondary vegetation (SV), forest plantations of *Eucalyptus globulus* Labill. (EUC) and *Pinus patula* Schltdl. & Cham. (PIN), and pastures (PAS). This recovery process started in the mid-1980s (Moreno et al. 1997) in the Metropolitan Regional Natural Park (MRNP) Cerro El Volador, located in Medellín-Colombia.

Materials and methods

Site and plant cover description

The study was carried out at the MRNP Cerro El Volador, located in the geographical centre of the Aburrá Valley, with geographical coordinates 6°15′ N and 75°34′ W. The park has a total area of 119 hectares and its altitudinal range varies between 1 468 and 1 628 m a.s.l. (Figure 1). The average annual rainfall is around 1 626.30 mm, with bimodal distribution along year; the mean annual temperature ranges between 17 and 28.5°C and corresponds to the life zone pre-montane moist forest (IDEAM 2017).

Geologically, the MRNP is located on strongly weathered amphibolite, with the development of residual soils of a thickness greater than 20 m (Gallego and Vargas 2011). The soils in the study area are classified as Ultisols with a thick argillic horizon (Jaramillo 2017, personal communication). Soil textures vary between sandy-clay-loam for EUC and PIN and clay-loam for SV and PAS, with bulk densities ranging from 0.99 to 1.04 g cm^{-3}.

In each vegetation cover type, three plots of 400 m^2 were established in which the diameter and height structure as well as basal area were calculated for trees with diameter at breast height (DBH) > 0.1 m. The SV coverage had a basal area of 6.08 m^2 ha^{-1} and 873 trees ha^{-1} distributed over 20 different species; the PIN had a basal area of 15.75 m^2 ha^{-1} and 1 538 trees ha^{-1}; and the EUC had a basal area of 16.33 m^2 ha^{-1} and approximately 1 485 trees ha^{-1} (Table 1). Three different species of the family Poaceae were found in PAS: *Brachiaria decumbens*, *Megathyrsus maximus* (Jacq.) B.K.Simon & S.W.L.Jacobs and *Paspalum* sp. (*Brachiaria decumbens* is now called *Urochloa eminii* (Mez) Davidse according to *World Flora Online*.)

Soil sampling and analysis

For each vegetation cover, three 10 m^2 sampling plots were established. The soil conditions were selected to be as similar as possible to allow valid comparisons between them. In each plot, five subsamples of soil weighing 300 g each were taken to form a composite sample at each soil depth as follows: one from the organic horizon (O) and two from the A horizon at 0–10 and 10–20 cm, respectively.

Bulk density was determined by the soil core method (Blake and Hartge 1986), with a cylinder of 64.45 cm^3 and five subsamples per plot. Soil texture was determined by the hydrometer method (Gee and Bauder 1986). Organic carbon content was determined by oxidation of soil samples with potassium dichromate according to the method described by Walkley and Black (1934). Thereafter, SOC stocks were calculated as follows (Equation 1):

$$SOC = C_{org} \times Bd \times Eh \quad (1)$$

where SOC = organic C stored in soil (Mg C ha^{-1}); C_{org} = grams of C in 100 g of soil; Bd = soil bulk density (g/cm^{-3}); and Eh = soil horizon thickness (cm).

Characterisation of soil organic matter

Extraction of humic substances (HS) was performed according to the Nagoya method described by Kumada (1987). After separation of HS fractions, C content in each fraction was determined as described previously.

The humification ratio (HR) index was used as a ripening indicator that measured which component (HA or FA) was predominant in the soil (Equation 2). A low ratio (HAC/FAC < 1) implied a low degree of humification. In addition, it may reflect the formation of complex molecules (HA) from simpler molecules (FA) and a decrease of non-humic components in the fraction of FA, which were more easily degraded by microorganisms (Zamboni et al. 2006).

$$HR = HAC/FAC \quad (2)$$

Where HR is the humification ratio; HAC is humic acid C; and FAC is fulvic acid C

The E4/E6 ratio is an index which provided information on the degree of condensation of HA and was based on the optical densities of HS extracts measured on an atomic absorption spectrophotometer at 465 and 665 nm (Chen et al. 1977). High values of this ratio (E4/E6 > 5) reflected a low degree of aromatic condensation with a predominance of aliphatic structures while values of E4/E6 < 5 showed a condensation process of the carbon molecule (Hiradate et al. 2006).

The degree of humification is a system of classification of HA based on two parameters. The first parameter is Δ log K (Equation 3); the second parameter is RF, which measures the relative color of HA from the titration of 30 mL of the HA solution used to determine the UV-Vis spectrum with 0.1 N$KMnO_4$ (Equation 4).

$$\Delta \log K = \log K400 - \log K600 \quad (3)$$

Where: LogK400 is the logarithm of the absorbance value of the HA extract read at 400 nm; LogK600: is the logarithm of the absorbance value of the HA extract read at 600 nm, measured on the atomic absorption spectrophotometer.

$$RF = K600 \times \frac{1000}{C} \quad (4)$$

Where K600 is the absorbance value of the HA extract read at 600 nm; and c is the volume of $KMnO_4$ titrated

According to the theory of HA genesis, there are four groups: A, B, Rp, and P. The humification process commences with group Rp, which includes the first states of humification of SOM; these then evolve into group B and eventually into group A. In strongly acidic soils, the Rp-type is replaced by group P, which corresponds to immature states of humification. The definition of AH groups is done

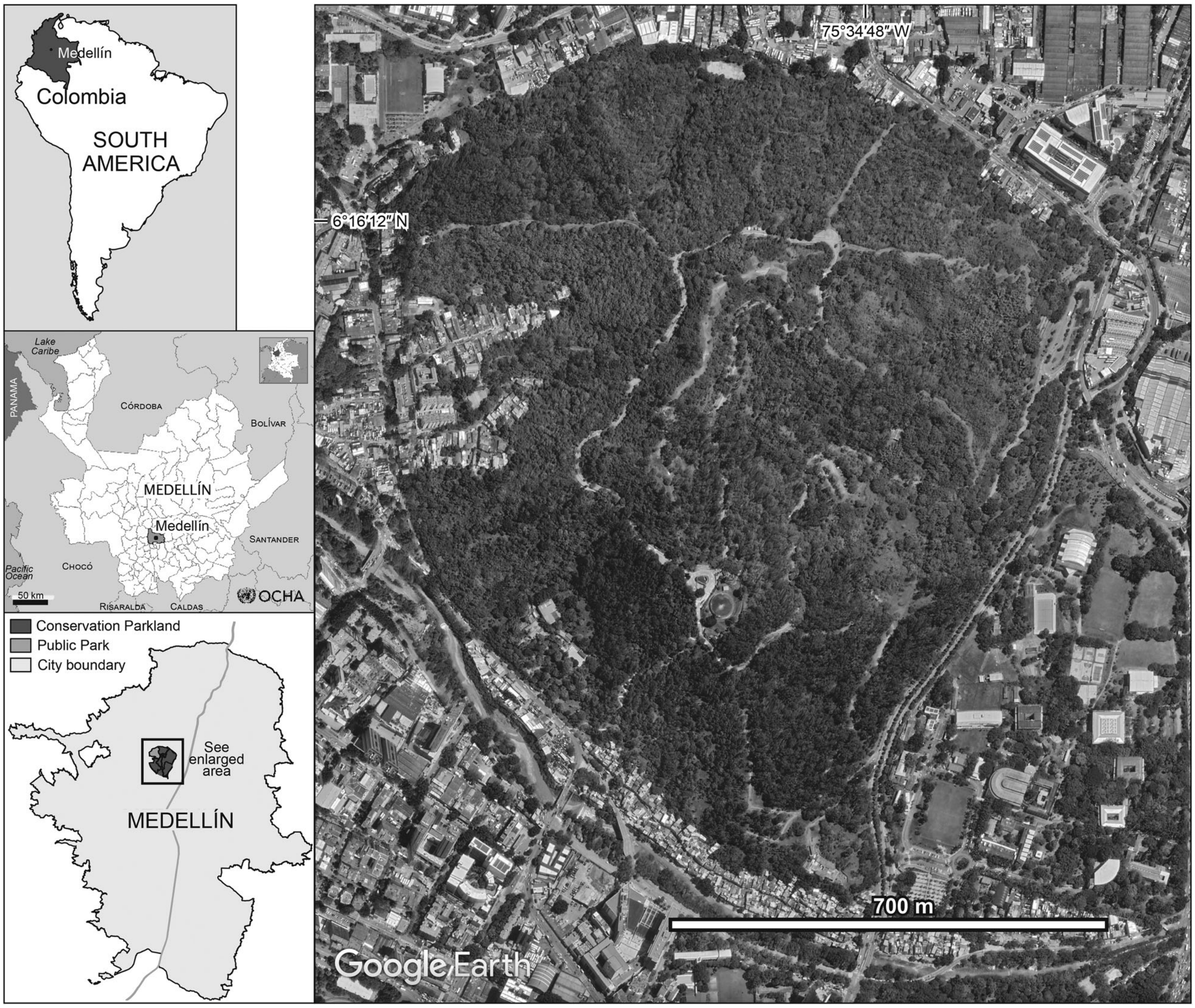

Figure 1: Location of the study area

in a Cartesian plane with values of Δlog K and RF (Kumada 1987).

Data analysis

Results were analysed using multifactorial analysis of variance (ANOVA) in an experimental design of split plots, where plant cover corresponds to large plots and soil depths to small plots. The Tukey mean comparison test was performed for parametric analyses with a significance level of 0.05. Data were processed with the statistical package R 4.1.2 (The R Foundation 2021).

Results

Soil organic carbon (SOC)

Soil Organic Carbon stocks in the O horizon were significantly higher ($p < 0.05$) in the soils under PIN (10.57 Mg C ha^{-1}) and EUC (9.71 Mg C ha^{-1}), followed by SV (8.67 Mg C ha^{-1}), and lowest in PAS (5.50 Mg C ha^{-1}). At the two soil depths evaluated in the A horizon (0–10 and 10–20 cm), SOC stocks showed significant differences between vegetation coverages but were not significantly different between the two soil depths for the same vegetation coverage. There was a slight decrease in the soils at the depth of 10–20 cm. The highest SOC stocks of the A horizon were recorded in EUC (0–10 cm = 50.74 Mg C ha^{-1} and 10–20 cm = 49.85 Mg C ha^{-1}), followed by PAS (0–10 cm = 39.82 Mg C ha^{-1} and 10–20 cm = 35.73 Mg C ha^{-1}); PIN (0–10 cm = 36.24 Mg C ha^{-1} and 10–20 cm = 30.46 Mg C ha^{-1}) and SV (0–10 cm = 30.69 Mg C ha^{-1} and 10–20 cm = 25.84 Mg C ha^{-1}) (Figure 2). According to these results, C stocks in the A horizon of SV were almost half of those in EUC.

Characterisation of soil organic matter

Carbon content in humic substances

The percentage of HAC in the O horizon was significantly higher ($p < 0.05$) in PIN and EUC (0.07%), followed by SV (0.04%); the lowest percentage was recorded in PAS (0.02%). In the A horizon, the highest percentages of HAC

Table 1: Forest structure of evaluated plant coverages: secondary vegetation (SV), *Eucalyptus globulus* (EUC), and *Pinus patula* (PIN)

Variables	Plant coverage		
	SV	EUC	PIN
Basal area (m^2 ha^{-1})	6.08 ± 0.04	16.33 ± 0.02	15.75 ± 0.03
Number threes ha^{-1} (DBH > 0.1m)	873 ± 0.08	1485 ± 0.05	1538 ± 0.04

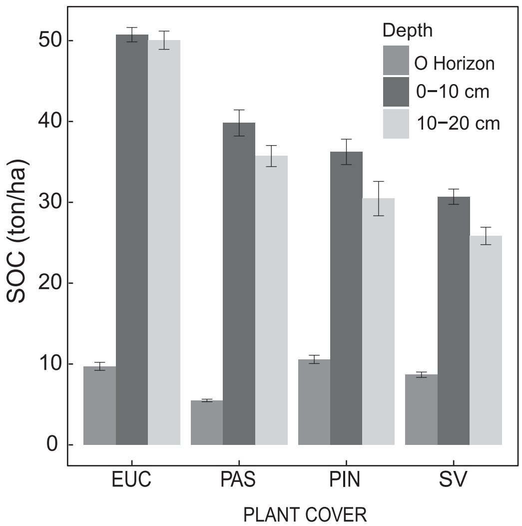

Figure 2: Levels of SOC stocks in soils under *Eucalyptus globulus* (EUC), pastures (PAS), *Pinus patula* (PIN) and secondary vegetation (SV) at different soil depths. Different letters indicate statistically significant differences among coverages. Vertical bars represent the standard error

were found in EUC (0–10 cm = 0.55% and 10–20 cm = 0.51%), followed by PAS (0–10 cm = 0.49% and 10–20 cm = 0.48%), PIN (0–10 cm = 0.49% and 10–20 cm = 0.45%); while the lowest percentages were found in SV (0–10 cm = 0.29% and 10–20 cm = 0.19%) (Figure 3a).

The percentage of FAC in the O horizon did not show significant differences between EUC, PAS and PIN; the lowest values were recorded in SV (0.04%). In the A horizon, the highest percentages of FAC were found in EUC soils (0–10 cm = 0.58% and 10–20 cm = 0.64%), followed by PAS (0–10 cm = 0.50% and 10–20 cm = 0.49%) and PIN (0–10 cm = 0.49% and 10–20 cm = 0.51%); the lowest percentages were found in SV (0–10 cm = 0.29% and 10–20 cm = 0.27%) (Figure 3b). The percentage of C in the total humic extract (THEC) in the O horizon did not show significant differences between EUC (0.14%) and PIN (0.12%), or between SV (0.06%) and PAS (0.09%). In the A horizon, the highest percentages of THEC were obtained in EUC (0–10 cm = 1.12% and 10–20 cm = 1.15%), followed by PAS (0–10 cm = 0.99% and 10–20 cm = 0.97%), PIN (0–10 cm = 0.99% and 10–20 cm = 0.96%) and SV (0–10 cm = 0.57% and 10–20 cm = 0.46%) (Figure 3c).

The AHC/AFC ratio produced values close to 1 in the evaluated vegetation covers. In the O horizon, values obtained in SV and PIN were higher than 1 and significantly higher than those obtained in EUC and PAS. In the A horizon, there were no significant differences in the 0–10 cm soil depth between the different covers. In the 10–20 cm soil depth, PAS had significantly higher values than the other vegetation covers followed by PIN; SV and EUC had the lowest values of this relationship and did not differ significantly from each other (Figure 3d).

E4/E6 ratio

The E4/E6 ratio was higher than 5 in soil extracts of all the vegetation covers evaluated, with little variation among soil depth levels and vegetation covers (no significant differences). However, values of this relationship were slightly higher in the O horizon of all covers (Figure 4). The lowest value of E4/E6 was recorded at 10–20 cm soil depth in the A horizon of EUC (6.32) and the highest value was in the O horizon of SV (9.48).

Degree of humification

The values obtained of Δlog K and RF made up two groups: the first one constituted by samples of the O horizon, and the second one by samples of the A horizon, with very little difference among them. They were characterised by lower Δlog K and slightly higher RF values with respect to the O horizon; however, both groups belonged to the HA of group P (Figure 5).

Discussion

Effect of restoration of vegetation cover on SOC storage

The lower SOC values found in the O horizon, as compared to the two soil layers of the A horizon (Figure 2), could be due to the moderately hot and humid climatic conditions of the study area (IDEAM 2017), which lead to fast decomposition of SOM in the O horizon and its early incorporation into the A horizon. It has been well-established that environmental factors such as humidity and temperature are determining factors in the storage of SOC in the O horizon, because they influence both the development of vegetation and the decomposition of SOM (Thaiutsa and Granger 1979). In addition, the O horizon presents a higher degree of aeration because of its superficial location and close contact with the atmosphere. In addition, having fresher SOM, it retains less moisture than the A horizon, where SOM is more decomposed and has greater moisture retention capacity, which protects it from mineralisation (Johnston 1991). According to Olson (1963), the storage of undecomposed organic compounds in tropical ecosystems is low compared to ecosystems in cold temperate zones. In the latter, the accumulated SOM is high because of the lower biological activity and hence

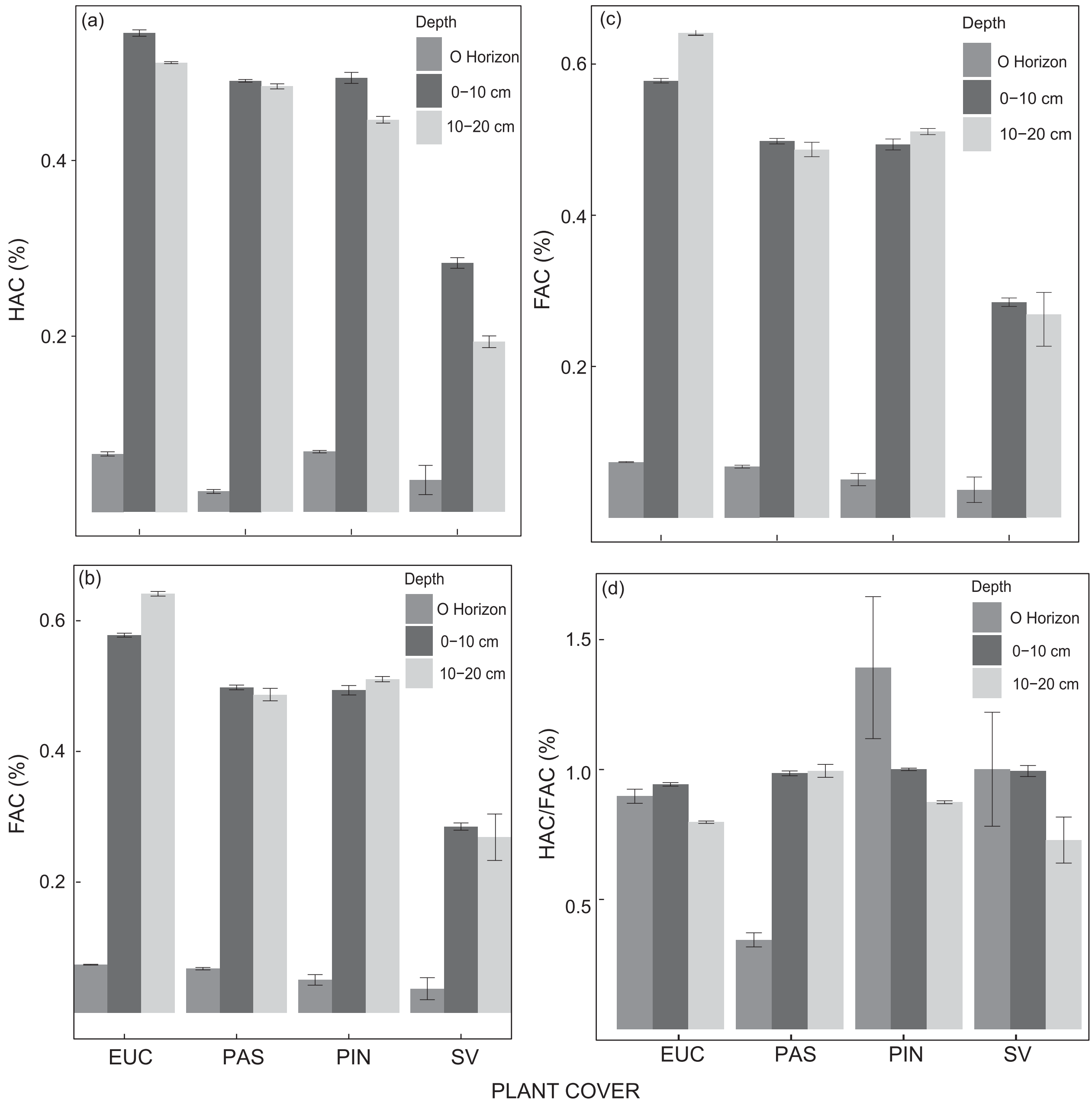

Figure 3: Carbon percentages in humic substances of soils of *Eucalyptus globulus* (EUC), pastures (PAS), *Pinus patula* (PIN) and secondary vegetation (SV), at different soil depths: (a) carbon in humic acids (AHC%); (b) carbon in fulvic acids (FAC%); (c) carbon in total humic extract (THEC%); and (d) humification ratio (HAC/FAC%). Values marked with different letters indicate statistical differences among coverages. Vertical bars represent the standard error

low decomposition rates associated with low temperatures. The SOM mineralisation increases with temperature, reaching its maximum between 30 and 40 °C. For these reasons, at low temperatures more residues are produced than are decomposed and organic matter increases; in contrast, as temperature increases the SOM decreases (Fassbender 1982).

Vegetation cover types affected SOC storage and distribution differently in the evaluated soil horizons. The significantly higher storage of SOC in the O horizon of PIN and EUC may be due to their higher basal area and number of trees per hectare than SV (Table 1). Consequently, the higher biomass and occupation of these ecosystems results in higher values of net primary productivity and organic litter production than in the SV and PAS coverages (Lugo 1992). Furthermore, it has been shown that litter produced by trees of the genera *Eucalyptus* and *Pinus* is rich in aromatic and lignified compounds, which decompose slowly, favoring its prolonged maintenance in the mulch (Berg 2000).

The SOC stocks in the A horizon showed significant differences between all the vegetation coverages (Figure 2).

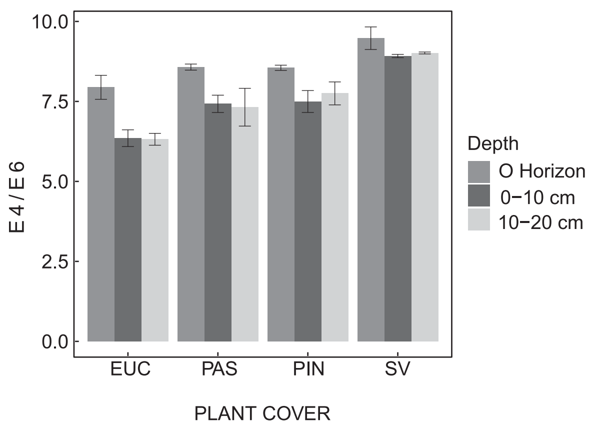

Figure 4: Mean values of the E4/E6 ratio of HA in soils under *Eucalyptus globulus* (EUC), pastures (PAS), *Pinus patula* (PIN) and secondary vegetation (SV) at different soil depths. Vertical bars represent the standard error. There were no significant differences between coverages

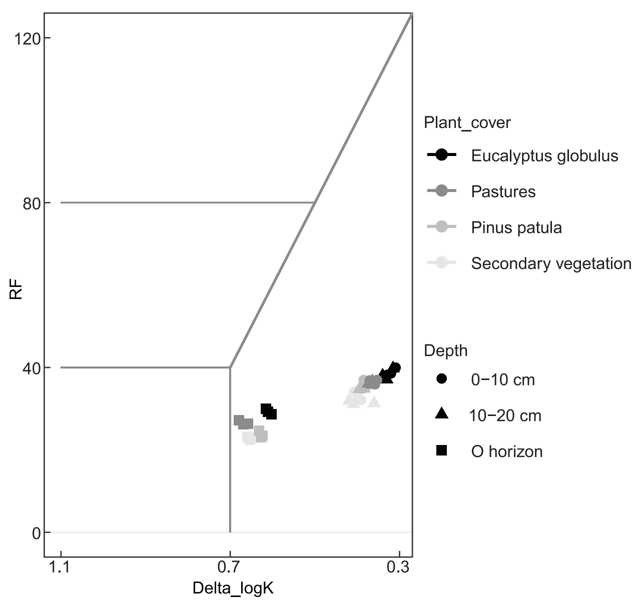

Figure 5: Characterisation of HA in the soils of plant covers studied (Jaramillo 2011)

In EUC they were significantly higher compared to the other coverages at both soil depths. Such results can be partially explained by the fact that most of the residues of this species are lignified and recalcitrant. Several studies have shown that plant residues that are rich in aromatic compounds and lignified, such as those of EUC, decompose more slowly, which favours the persistence of SOM in the soil (Berg 2000; Kuzyakov and Domanski 2000).

The PAS coverage, despite having the lowest SOC content in the O horizon, had significantly higher SOC content in the A horizon than the PIN and SV soils. These results were in accordance with other authors (Vicente et al. 2016), who found significantly higher SOC contents in soils under pastures compared to areas of secondary vegetation and forest plantations. However, other studies found a net decrease in SOC stored in pasture soils compared to natural forests (Moreno et al. 2017). These contradictory results in the SOC stocks for this type of coverage seem to arise from differences in the sampling scheme (for example, superficial vs. deep sampling), differences produced by the management and use of the pasture (intensive vs. extensive), or pasture age (De Koning et al. 2003). Grassland management has a great effect on SOC storage. It has been found that low-productivity extensive livestock systems, commonly practised in many tropical countries, are associated soil compaction and erosion. Under these conditions, the pasture has low productivity and therefore a low contribution of plant debris (Ibrahim et al. 2013). However, in ungrazed grasslands (such as those in the present investigation, which were abandoned several decades ago), all of the grass production returns as detrital material to the ground, which would explain the increase in SOC (Cerri et al. 2004; Vicente et al. 2016). Many grasses are perennial plants with high root production. Grass species allocate about 30–50% of the fixed C to the formation and maintenance of a voluminous, fine and deep root system that is constantly recycled (Kuzyakov and Domanski 2000). They have a short half-life (Conant et al. 2001) with a high recycling rate and therefore contribute high levels of dead roots to the soil (Cerri et al. 1991). Tree roots, on the other hand, are mostly woody and long-lived (Post and Kwon 2000). These differences may explain the high levels of SOC accumulation under the grassland.

Although the highest SOC contents in the O horizon occurred in PIN, storage of SOC in the A horizon decreased with respect to EUC and PAS. This decrease has also been reported in other studies (Bernhard-Reversat 1996; Turner and Lambert 2000), and may be due to the fact that there was little C incorporation from litter to the soil. According to Farfán and Urrego (2007), in humid forests of Colombia, of the plant material contributed by trees of *Pinus* (6.67 tonnes ha^{-1} year^{-1}) and *Eucalyptus* (6.39 tonnes ha^{-1} year^{-1}), 5% and 10.8% respectively were incorporated into the soil in the first 30 days, and 25.2% and 54% respectively on an annual basis. These results were explained by the higher decomposition rate of *Eucalyptus*; with values ranging between 0.37 to 0.42 kg year^{-1} for *E. globulus* (Ribeiro et al. 2011), while in trees of *Pinus*, values varied from 0.13 to 0.16 kg year^{-1} (Austin and Vitousek 2000). Due to the slow decomposition rate of the needles of PIN litter, the SOC contents in the top 10 cm of soil were generally low and old (Zinn et al. 2002). These characteristics of *Pinus* plantation litter were probably one of the causes of their lower SOC as compared to PAS. Pastures maintain a permanent cover of vegetation on the ground, with high rates of productivity and constant renewal of fibrous roots, which have a high density in the top 20 cm of soil, and contribution high levels of dead OM to the soil (Brown and Lugo 1990).

The low storage of SOC in SV may be related to the significantly lower development of this ecosystem, the greater diversity of woody and herbaceous vegetation species, and the great variation in the size of individuals.

The basal area and density of trees were much lower than those of the two forest plantations studied (Table 1), thus it is evident that SV had lower biomass and production of plant residues. Differences in root depth of plants and in the vertical stratification of the canopy, as well as the lower site occupation by vegetation, affect temperature regimes. These factors would have generated a lower demand of water for transpiration and consequently, increased soil water storage. These conditions accelerate the decomposition of OM; for example, more vigorous microbial activity has been reported under this layer (Ordoñez et al. 215). Therefore, in these areas, greater amounts of C than of CO_2 are probably lost by soil respiration. Both processes (i.e., lower production of plant residues and higher decomposition rates) in SV soils compared to PIN and EUC soils, explain the lower storage of SOC (Lal 2005). These results are in accordance with other studies (Bonfatti et al. 2016; Vicente et al. 2016) in which fast-growing forest species and pastures have higher SOC contents than secondary vegetation.

Effect of restoration of vegetation cover on the characteristics of soil organic matter

The significant differences in the C contents of HS among vegetation coverages (Figures 3a, b, c) showed that the type of vegetation cover affects the characteristics of SOM. The HAC percentages differed significantly among vegetation coverages, both in the O horizon and in the two soil layers in the A horizon. The higher C contents in the HS of the O horizon, both in PIN and EUC, could be explained by the fact that their litter contains more phenolic compounds that probably decreased the catabolic diversity of the microbial community and consequently C degradation (Nsabimana et al. 2004). Therefore, with a longer residence time, a larger quantity of organic compounds accumulates to be humified. This is the opposite of the conditions in PAS, where there was a frequent entry of fresh organic debris of a more easily degradable nature which could be used by the microbiota, thus contributing to a greater accumulation of FAC than of HAC (Hernández-Hernández et al. 2008). The lower C contents in HS of SV can be partially explained by the quantity, types and sizes of organic residues present in the litter. This would favour the diversity of edaphic fauna and the disintegrating activity of the microorganisms (Herrera and Cuevas 2003) and explain why fresh organic debris do not become humified (Balesdent et al. 2000).

The greater accumulation of C in HS in the A horizon (Figure 3c) is related to its recalcitrance, its adsorption by the mineral matrix of soil and its intra-aggregate occlusion (Mikutta et al. 2004). The accumulation of humified SOM is also related to fine soil particles with which the organic matter forms biochemically complex compounds resistant to microbial degradation (Stevenson et al. 1994). These organo-mineral complexes further stabilise the SOC (Accoe et al. 2004). The percentages of HAC and FAC were significantly higher in EUC as compared with the other vegetation coverages, which agrees with results reported by Lima et al. (2006). The results could be explained by the fact that plant components rich in aromatic and lignified compounds favour the permanence of higher levels of organic substances in the soil (Berg 2000). It is important to take into account that under aerobic soil conditions, a large part of the C entering the soil is labile and only a small fraction (1%) of what enters accumulates in the stable humic fraction (Robert 2002).

The highest value of the HAC/FAC ratio (Figure 3d) was found in the O horizon of PIN (1.53), and is related to the fact that litter of this vegetation coverage had the highest HAC content. Contrasting results were obtained in the O horizon of PAS, where the lowest values were recorded due to a higher content of FAC than HAC as a consequence of the continuous contribution of fresh OM that does not reach humification (Zamboni et al. 2006). In the 0–10 cm soil layers, there were no significant differences among coverages and the HAC and FAC contents were similar. However, in the 10–20 cm soil layers, there were significant differences among the vegetation coverages, with a higher content of FAC compared to HAC. This indicates that in this soil layer a greater amount of poorly humified and more soluble organic substances had accumulated (Jaramillo 2011). In general, the HAC/FAC values were less than or close to 1 in the soils studied, which indicated a slow process of evolution of SOM, due to the content of FA in the soil and a low degree of condensation of aromatic compounds (Rivero and Paolini 1994).

The E4/E6 ratio showed values of > 5 in all soils (Figure 4) but no trend related to land use was observed, nor were there significant differences among coverages. These results indicate that a poorly-evolved SOM was accumulating, with high levels of aliphatic chains and a simple humification process (Chen et al. 1977). The results obtained in the degree of polymerisation of the SOM agree with results for the evaluation of the degree of humification of humic acids, which are in group P, with low RF and Δlog K values (Figure 5). The results were characteristic of SOM with a low degree of humification in the different vegetation cover types. These results indicated that the humic fraction of SOM of these soils is formed by HA of low molecular weight with a high degree of polymerisation (Jaramillo 2011).

Conclusions

The results of this study revealed that reforestation with *Eucalyptus globulus* trees shows the highest potential for the accumulation of SOC in the top 20 cm of soil, in comparison with pastures, *Pinus patula* and secondary vegetation of the same age (approximately 30 years). The type of vegetation used in the cover restoration processes affected the C contents in the HS differently. It was also found that SOM of the different covers studied is mainly composed of fresh OM, which is evident in the low percentages of HAC (less than 1) and in the characterisation indices of SOM.

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GEOLOCATION

6°15′ N and 75°34′ W

ORCID

Víctor Mondragón — http://orcid.org/0000-0001-6742-6573
Flavio Moreno Hurtado — http://orcid.org/0000-0002-4634-5042
Daniel Francisco Jaramillo Jaramillo — http://orcid.org/0000-0002-9308-9897

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