Scattered Trees in a pasture matrix enhance Phosphate deposition in the soil via rainfall redistribution: role of structural and morphological traits

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Abstract

Tropical ecosystems exhibit a natural limitation in soil nutrients, sufficient to limit productivity, particularly in the mountains ecosystems, where geomorphology and climate result in high rates of soil erosion, exacerbated with forest fragmentation and forest loss. This is particularly important in Phosphorous, a limiting nutrient in mountain ecosystems. Scattered trees in fragmented landscapes have been designated as key structures due to their ecological functions that improve the biophysical and biogeochemical conditions of the place and can potentially serve as starters for vegetation recovery. Previous studies have demonstrated the importance of precipitation redistribution and interaction with the canopy for nutrient inputs into forests, where tree species differ in their responses because of their specificity, trait configuration, and plant community competitive hierarchies. However, few studies have quantified the effect of functional traits, for different species of scattered trees, on their capacity to intercept and move phosphorus through precipitation partitioning. In this study, we determined the association between 12 plant functional traits and Phosphorous movement from the canopy into the soil in 20 individuals of five tree species scattered across a human-altered montane landscape in the Colombian Andes : *Croton magdalenensis, Andesanthus lepidotus, Vismia Baccifera*, and *Quercus humboldtii*, and a commonly-planted exotic species *Eucalyptus globulus*. We quantified PO_4-P concentrations in precipitation, throughfall, and stem flow in all trees for a group of 14 individual rainfall events. In general, PO_4-P concentrations in precipitation (0.33 mgPO_4-P/l) were lower that the net concentration (Nc) in all species. One particular species, *C. magdalenensis*, had significantly higher values of PO_4-P concentration in throughflow 1.27 mgPO_4-P/l and stem flow 7.01 mgPO_4-P/l. This condition potentially results from a particularly higher epiphyte, leaf area and trichome density in this specie, that potentially facilitate biogeochemical exchange and improve ecological functions associated with the early stages of forest recovery. Further, canopies can potentially transport phosphate to the soil, which helps to reestablish important biogeochemical processes in the first stages of restoration of degraded ecosystems.

1. Introduction

The availability of nutrients in ecosystems is conditioned by their natural occurrence on the earth's surface and the efficiency of transport mechanisms that mobilize them (Doughty et al., 2016). Phosphorus (P) is the most common nutrient limiting primary productivity in ecosystems (Kong et al., 2020). Its natural mobilization is part of the denudation-geotectonic elevation cycle (Reed et al., 2015). Besides, its low solubility and the rapid conversion of phosphate to insoluble forms make it difficult for plants to integrate it from the soil (Wang & Lambers, 2020). This low supply can affect the concentration in leaves and decrease orthophosphate (PO_4-P) deposits that reduce the net CO_2 assimilation rate and other components of photosynthetic biochemistry (Veneklaas et al., 2012), which effects he structure and composition of the ecosystem (Zhou et al., 2018).

Tropical soils have a higher P limitation than temperate and polar ecosystems (Hou et al., 2020), due to the depletion of P during long-term pedogenesis, sufficient to limit productivity in old and eroded soils that characterize part of the tropical biome (Vitousek et al., 2010). This is particularly evident in mountainous areas, where geomorphology and climate lead to high soil erosion (Suescún et al., 2017). Phosphorus limitation is particularly intense in the Andean ecosystems, where fragmentation and forest loss of forests (Wilcke et al., 2019); modify biophysical, hydrological, and biogeochemical processes, ultimately affecting ecosystem functions (Balthazar et al., 2015). Therefore, the bioavailability of P for tree species that grow in the soils of tropical montane forests depends, to a great extent on the mineralization of the thick organic layers that frequently host a large part of the plant roots (Wilcke et al., 2019), and the internal circulation of PO_4-P in which plants can take advantage of the limited contributions of this nutrient through the interception of precipitation (Zhao et al., 2017).

Atmospheric deposition represents an important input of P to the ecosystem, and more so when it is related to hydrological processes such as precipitation (Chiwa, 2020). Bulk precipitation is partitioned into interception loss, throughfall, and stem flow as it passes through the forest canopy (Ponette-González, et al., 2020). Throughfall is the main water entry into the understory, becoming a direct source of nutrients for plants and

microorganisms (Su et al., 2019), therefore, a key regulator of biogeochemical dynamics on the surface (Kumar Gautam et al., 2017). Stem flow is typically much lower (in quantity) than throughfall (Van Stan & Allen, 2020) but still important in biogeochemical terms. Both of these fluxes of water and dissolved minerals can directly alter the physical-chemical properties of the root zone and accelerate the redistribution of nutrients in forest ecosystems (Su et al., 2019). Consequently, rainfall partitioning directly determines the active role of tree canopies in the biogeochemical dynamics of forest ecosystems and, more importantly, are fundamental for the provision of ecosystem services and the maintenance of the regulatory functions of ecosystems (Mori et al., 2017).

Colombian mountainous landscapes have been highly modified by agricultural and livestock expansion, leaving a fragmented landscape where small remnants of forest and scattered trees are immersed within a highly transformed matrix (Rubiano et al., 2017). Previous studies have highlighted the ecological importance of these scattered trees based on the ecological functions they have relative to the area they occupy, allowing to improve biophysical and biogeochemical conditions of the site (De Boever et al., 2015). At a Landscape-scale, scattered trees modify spatial heterogeneity and contribute to ecological connectivity that helps plant species dispersal (Prevedello et al., 2018). Nutrient availability under scattered trees generally increases in response to different factors such as biomass accumulation (Rivest et al., 2013), decomposition and microbial activity (Le Roux et al., 2018), and the interception of nutrients from wind and hydrological processes such as precipitation and fog (Vandecar et al., 2015). These processes facilitate the recruitment of other species (Prevedello et al., 2018), allowing biogeochemical exchange and the capacity to improve ecological functions associated with the early stages of forest recovery (Siqueira et al., 2017).

The interactions between precipitation and elements of the forest canopy (bark, leaves, and epiphytes) control the quantity, the spatial-temporal patterns, and the chemical concentration of the precipitation that reaches the soils (Van Stan & Pypker, 2015). The structural and morphological characteristics of each plant and the characteristics of hydrological events are key in the interception of nutrients (Aparecido et al., 2018; Ginebra-Solanellas et al., 2020; Silva et al., 2020). Aspects such as forest type, its physical structure (Voss et al., 2016),

epiphyte cover (Van Stan & Pypker, 2015), and functional traits have been demonstrated to increase nutrient inputs to tropical montane ecosystems (Báez & Homeier, 2018). In addition, multiple Phosphorous recycling strategies have been reported in different plant species, under conditions of low soil availability in the soil (Dissanayaka et al., 2018; Mo et al., 2019; Wang & Lambers, 2020). However, to our knowledge, the interspecific variation in the partition of precipitation and the influence of functional traits in the circulation of PO_4-P, have not been reported in the literature for scattered trees species in Tropical Andean mountains regions. Such knowledge is important to inform restoration programs directed towards the reestablishment of biogeochemical processes in fragmented landscapes.

In this study, we evaluate the effects of functional traits in scattered trees on the interception and deposition of PO_4-P, to determine like the variation in the combination of functional traits between species can affect the amount of PO_4-P that reaches the soil. We start from two hypotheses: (I) There is a positive relationship between the presence of scattered trees in fragmented landscapes and the enrichment of phosphate on rainfall, and
(II) Can functional traits influence PO4-P concentrations that reach the soil. We measured 12 functional traits in 20 individuals of four native species and one commonly-planted exotic species in modified montane ecosystems of the tropical Andes. We also measured, precipitation partitioning into throughfall and stem flow, and the concentration of PO_4-P in all fluxes for 14 individual precipitation events in different rainy seasons. Finally, we discuss how the traits of each individual interact with the water flows and the concentration of PO_4-P that reaches the soil and how the presence of these scattered trees can influence the loss or enrichment of PO_4-P that reaches the ecosystem.

2.MATERIALS AND METHODS

2.1 Study site

The study area is located in the municipality of Bello, department of Antioquia, in the central region of the Colombian Andes (06°21’03,09’’N; 75°36’57,05’’W; figure 1), This area is characterized by hills with high slopes, the area corresponds to a humid montane forest ecosystem (2,650 m a. s. l), according to the Holdridge life zone classification. The landscape is generally dominated by pasturelands for dairy cattle mixed with agricultural crops, sparse

patches of natural forests, and scattered trees. The main parent material of the soils in this mountain range is constituted volcanic ash (Jaramillo 2006). The mean annual precipitation is 1,756 mm, with a bimodal regime: two wet seasons (March to May; September to November) and two dry seasons (December to February, June to August).

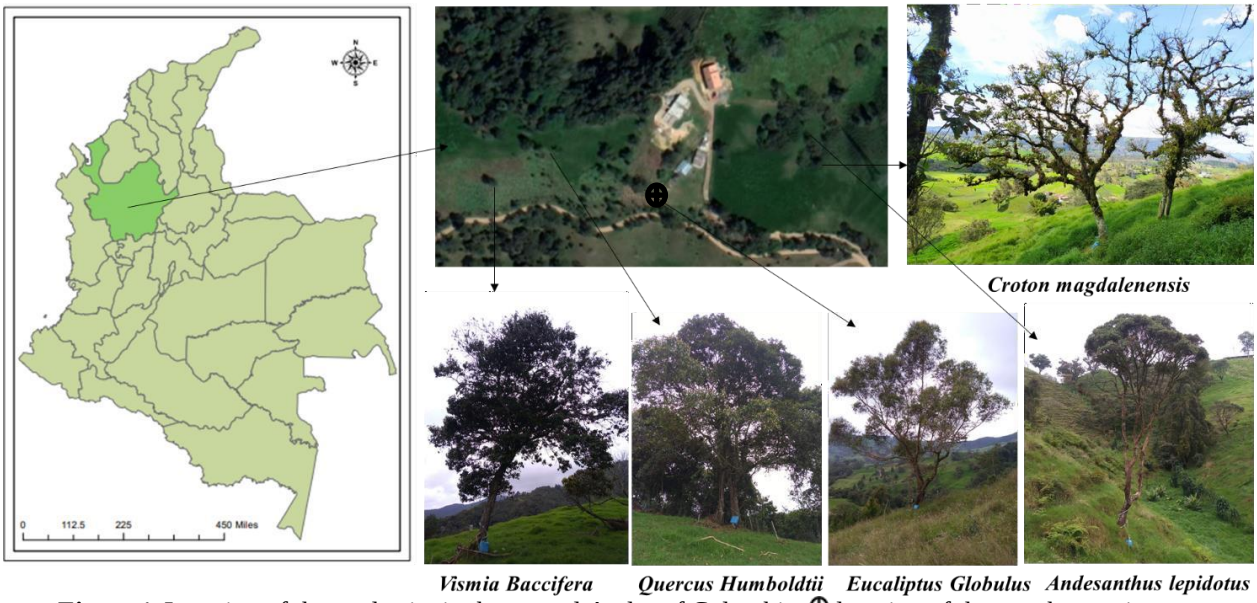


Figure 1. Location of the study site in the central Andes of Colombia, ⊕ location of the weather station.

2.2 Species selection and distribution

Scattered trees are mature trees in a fragmented forest that occur an incidental occurrence in grass matrices in isolated and open patterns (Figure 1). We evaluated the dynamics of rainfall partitioning and PO_4-P concentrations reaching the soil on twenty individuals from five tree species, all scattered within the grass matrix in a modified Andean forest: *Croton magdalenensis* Müll Arg, *Andesanthus lepidotus* Bonpl, P.J.F.Guim. & Michelang, *Vismia baccifera* Triana & Planchon, and *Quercus humboldtii* Bonpl. All of these species are dominant and native to the Northern Andes. We also included common exotic species in the area *Eucaliptus globulus* Labill, generally planted for timber.

2.3 Field instrumentation

Two 4-inch diameter cylindrical rain gauges were placed in the open field to measure the incoming precipitation (Pi) and the orthophosphate concentrations mgPO_4-P/l at a height of 1.25 mt from the ground. The concentrations PO_4-P in Stem-flow (Sf) and Throughfall were evaluated in four individuals per species. On each individual, two rain gauges were installed

to collect the Th corresponding to the amount of rain that reaches the ground after crossing the canopy. To measure Sf, stem collars were installed in each tree. This was arranged helically in each tree, guaranteeing the total coverage of its diameter, and was attached to a 40-liter container. Weather variables were monitored (Precipitation amount, precipitation intensity, temperature, relative humidity, wind speed, and direction) Every 30 minutes with a Davis Vantage Pro2 station for the entire monitoring period.

2.4 Functional traits measurement

We selected a group of plant functional traits that directly relate resource interception, rainfall partitioning, and surface water flow (Oliva Carrasco et al., 2015; Gonzalez-Ollauri et al., 2020). In total, 12 functional traits were measured in each individual: Crown Height (CH), Crown Area (CA), Crown Density (CD), Density x Volume (DxV), Epiphytes Cover (EC), Bark Text (BT), Diameter (DM), Leaf Area (LA), Specific Leaf Area (SLA), Maximum Water Retention (MWR), Dry Foliar Matter (DFM), Retention Angle (RA), Trichome Density (TD). These functional traits were measured under standardized protocols (Garnier et al., 2013; Díaz et al., 2016; Salgado-Negret, 2016), which were adapted according to the nature of each individual and detailed in (Appendix 1).

2.5 Hydrological Sampling and chemical analysis

We quantified concentrations of PO_4-P (mgPO_4-P/l) in Pi, Th, and Sf in all individual tree species for a group of 14 individual rain events, distributed from October 2020 to May 2021 (Appendix 2). Volumetric measurements were taken for Sf in each individual and combined samples were taken from the rain gauges for Pi and Th. After collection, water samples were refrigerated and transported to the laboratory (Acuazul Ltda) the same day, where the determination of PO_4-P was carried out following the ion chromatography method. The measurements were carried out in contrasting hydrological periods (October-November), (March-May) humid weeks, and (December-February) dry weeks, according to the rainfall regime in the area. Each precipitation event was characterized based on the hydrological characteristics (intensity, duration, magnitude, and dry spell duration), and meteorological (temperature, relative humidity, wind speed, and direction).

2.5.1 Hydrological and orthophosphate fluxes

The volumes per precipitation event in Pi and Th were converted to water depth (mm), dividing them by the collection area of the rain gauges. For Sf measurements, the volume of water collected in the collars was divided by the basal area of each tree (following protocols in (García-Leoz et al., 2018). Net precipitation (Np) and interception (I) were calculated as Np = Th + Sf and I = Pi - Np.

The orthophosphate fluxes (mg/m²) in each individual event/tree were calculated as the product between the mean PO_4-P concentration mgPO_4-P/l and water depth of Pi, Th, and Sf, for event on each tree. Net concentration (Nc) of PO_4-P in each individual is determined as the weighted average between Th and Sf.

Net PO_4-P flux (Nf) was calculated as is the difference between the amount of PO_4-P in precipitation and the Nc of PO_4-P (Parker, 1983), based on the equation:

$$Nf = A*[\ Nc[PO_4\text{-}P] * Np] - [P[PO_4\text{-}P] * Pi]$$

Where Nf is Net flux (mg/m²), A is the crown area (m²), Nc [PO_4-P] is the net concentration PO_4-P (mg/l), Np net precipitation (mm), PO_4-P is the concentration of PO_4-P in the rain (mg/l), Pi is the precipitation (mm).

To determine how PO_4-P circulates within tree canopies, we used the concentration ratio (Cr), this was calculated as the ratio of PO_4-P concentrations in Th and Sf to precipitation (Parker, 1983). Concentration Ratio values > 1.0, indicate enrichment of PO_4-P as water passes through the canopy, while values under 1.0 indicate impoverishment and PO_4-P capture in the canopy.

Normality and homogeneity of variance were checked for functional traits, hydrological flows, and PO_4-P concentration using Shapiro-Wilk's W test and Levene tests. Due to the non-normal nature of the data, a Kruskal–Wallis (non-parametric) test was used to compare volumetric fluxes and phosphate concentrations in Th and Sf between species and events.

When significant differences emerged from the Kruskal-Wallis test, specific differences between individual species were determined using a post-hoc Wilcoxon signed-rank test.

2.5.2 Relationship between functional traits, water fluxes, and PO_4-P concentration

We determined associations between the concentration and fluxes of PO_4-P with functional traits using Spearman's correlation coefficients and principal component analysis (PCA). Associations between individuals based on the combination of traits and PO_4-P circulation were explored using a hierarchical cluster and PCA. Also, the different distances (Euclidean, Mahalanobis, Minkowski) and grouping techniques (Ward, Media, Mcquitty) were performed. To choose the best grouping, the cophenetic correlation coefficient was evaluated in each combination.

2.5.3 Relationship between Nc and Cr with the hydrological and meteorological characteristics of precipitation events

Average values of the hydrological characteristics (intensity, duration, magnitude, and dry spells) and meteorological (temperature, relative humidity, wind speed, and direction) were analyzed in each of the precipitation events (Appendix 1). We determined the associations between Nc and Cr of PO_4-P using Spearman's correlation coefficients and the comparison of average values between all individuals.

3. Results

3.1 Trait-variation in scattered tree species

C. magdalenensis and. *Q. humboldtii* were the species with the highest values in foliar traits (Table 1) such as leaf area (180.57 cm^2; 99.42 cm^2 respectively) and specific leaf area (96.88 cm^2/g; 102.74 cm^2/g). *C. magdalenensis* exhibited significant differences in leaf area with *E. globulus* ($P<0.05$); and *A. lepidotus* ($P<0.05$), while *Q. humboldtii* had significant differences with *A. lepidotus* in both leaf area ($P<0.05$) and specific leaf area ($P<0.05$). *E. globulus* had the lowest values in maximum water retention (0.005 g/cm^2) and the highest values of dry foliar matter (0.45 mg/g). Further, *E.globulus* had significant differences with *C. magdalenensis* in dry foliar matter ($P<0.05$). Trichome density was highest in *C. magdalenensis* (77.80%). The lowest values of trichomes occurred in *V. baccifera* (24.17%)

and *Q. humboldtii* (21.35%), while, *E. globulus* had no trichomes.

We found higher values for characteristic structural traits of the crown such as crown area (32.15 m²) and crown height (25.10 m²) in the introduced species *E. globulus*, without significant differences between species (P>0.05). Epiphyte cover was highest in *C. magdalenensis* (71.12 cm²), followed by *Q. humboldtii* (49.52 cm²). Significant differences were found with E. globulus (P<0.05), which had the lowest epiphyte cover (13.05 cm²). Higher roughness values for bark texture were observed in A. lepidotus (57.22), followed by V. baccifera (39.29). Q. humboldtii (28.88) and E. globulus (25.06) with the lowest values of bark roughness. However, differences were not significant among species for this trait.

Table 1. Mean and standard deviation values for **f**unctional traits analyzed: Crown Height (CH), Crown Area (CA), Crown Density (CD), Density x Volume (DxV), Epiphytes Cover (EC), Bark Text (BT), Diameter (DM), Leaf Area (LA), Specific Leaf Area (SLA), Maximum Water Retention (MWR), Dry Foliar Matter (DFM), Retention Angle (RA), Trichome Density (TD), in scattered tree species *Croton magdalenensis* (Cm), *Andesanthus lepidotus* (Al), *Vismia baccifera* (Vb), *Quercus humboldtii* (Qh), and *Eucalyptus globulus* (Eg). Superscripts indicate significant differences between species (Values with the same superscript are significantly different).

STRUCTURAL TRAITS

Species/Traits	CH(m)	CA (m²)	CD (%)	DxV	EC (cm²)	BT	DM (m)
Cm	12.8 ± 3.14	20.59 ± 7.37	47.22 ± 12.22	649.61 ± 129.20	71.12 ± 9.83^{c}	27.34 ± 6.35	1.17 ± 0.09
Al	11.04 ± 3.56	20.10 ± 6.56	53.86 ± 21.62	1010.00 ± 409.53	17.54 ± 10.43	57.22 ± 4.28	1.28 ± 0.31
Qh	15.8 ± 2.49	22.435 ± 5.12	73.26 ± 3.98	1575.33 ±588.47	49.52 ± 14.47	28.88 ± 3.25	1.31 ± 0.41
Eg	25.10 ± 9.86	32.15 ± 6.82	44.46 ± 14.47	5317.28 ± 2390.51	13.05 ± 6.38^{c}	25.06 ± 22.98	1.69 ± 0.60
Vb	10.75 ± 1.05	18.02 ± 3.89	53.14 ± 22.12	378.415 ± 159.85	24.44 ± 6.17	39.29 ± 11.69	0.92 ± 0.30

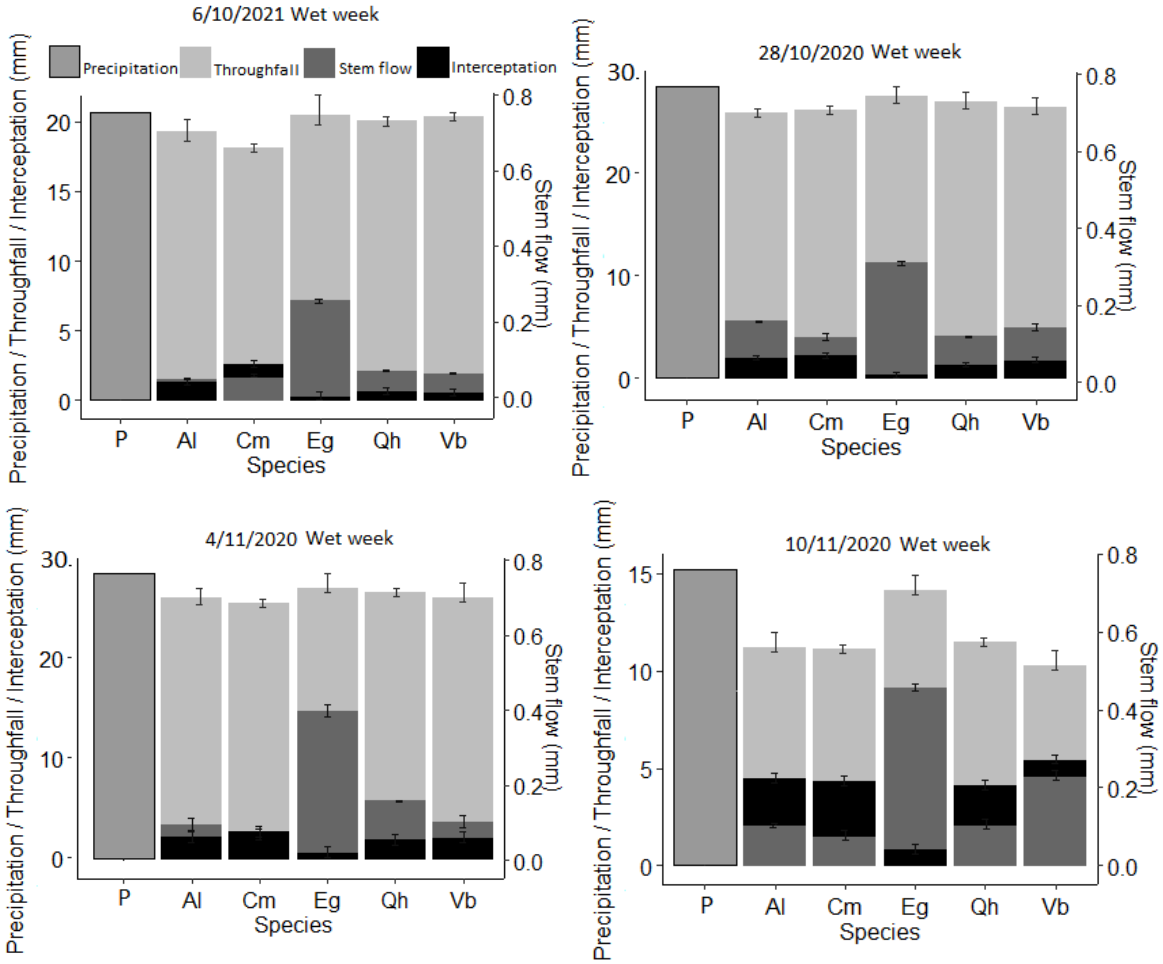
LEAF TRAITS

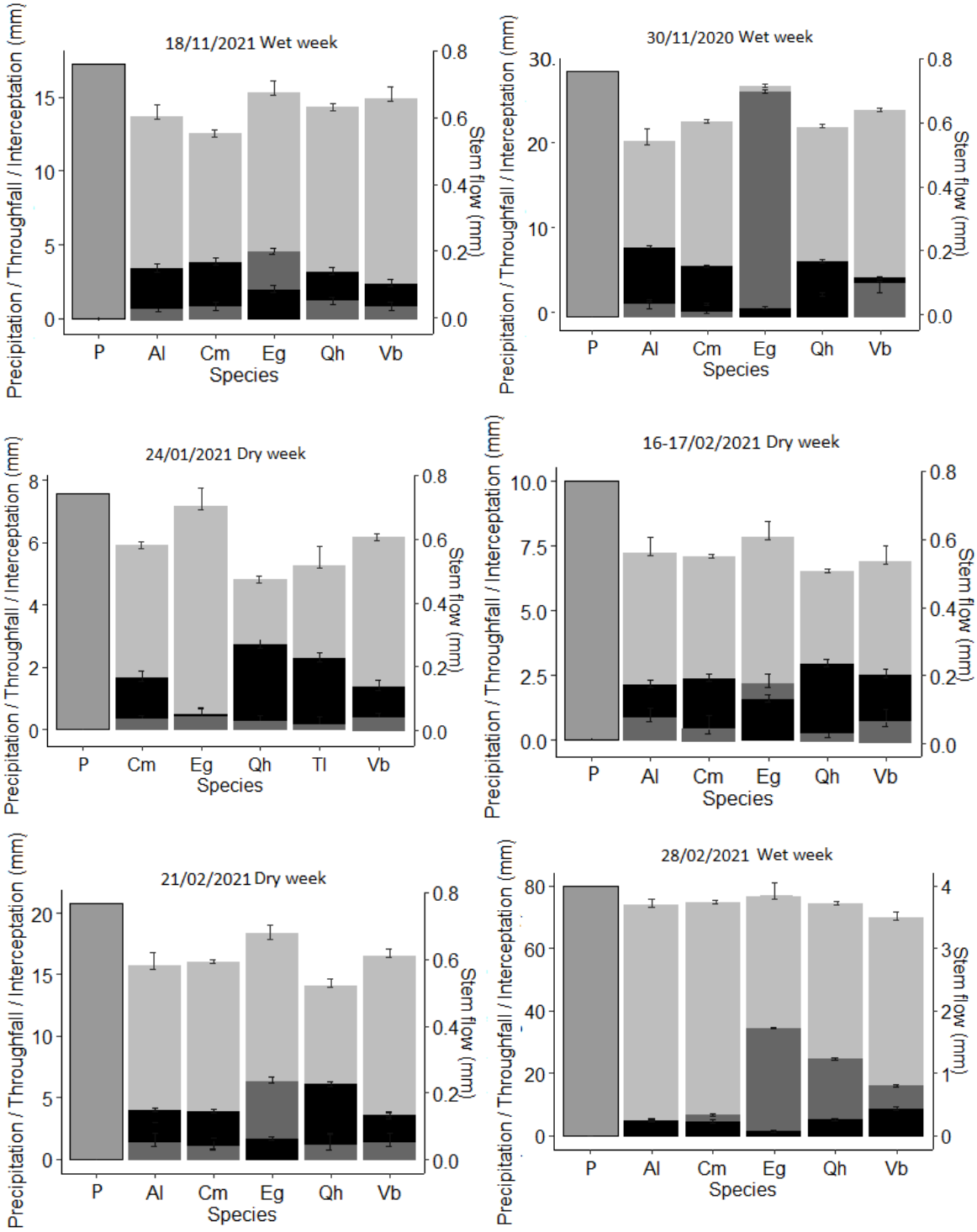
Species/Traits	LA (cm²)	SLA (cm²/g)	MWR (g/cm²)	DFM (mg/g)	RA (°)	TD
Cm	180.57 ± 112.14^{ac}	96.88 ± 7.37	0.019 ± 12.22	0.224 ± 129.20 ^{c}	0.475 ± 9.83	77.80 ± 6.35
Al	9.87 ± 5.56^{ab}	39.58 ± 6.56^{b}	0.010 ± 21.62	0.377 ± 409.53	1.102 ± 10.43	60.28 ± 4.28
Qh	99.42 ± 38.49^{b}	102.74 ± 5.12^{b}	0.009 ± 3.98	0.400 ±588.47	0.675 ± 14.47	21.35 ± 3.25
Eg	39.10 ± 15.86^{c}	65.25 ± 6.82	0.005± 14.47	0.455± 630.51^{c}	1.177 ± 6.38	-
Vb	61.75 ± 21.05	65.07 ± 3.89	0.006 ± 22.12	0.369 ± 159.85	0.663 ± 6.17	24.17 ± 11.69

3.2 Precipitation partitioning

Mean precipitation in all monitored events was 25mm ± (17.24 mm), ranging between 7.54 mm and 80.4 mm, Th was always dominant in precipitation partitioning, with values between 20.40 mm in *C. magdalenensis* and 23.55 mm in *E. globulus*, corresponding to ranging between 81.60% and 94.2% of incoming precipitation (Appendix 3), and no significant differences between the species (P>0.05). Sf had a comparatively low contribution to net

precipitation in all events with mean values between 0.14 mm in *C. magdalenensis* and 1.68 mm in *E. globulus*, corresponding to 0.56% and 2.68% of the total precipitation. Significant differences were only found (P<0.05) in Sf between *E. globulus* and *C. magdalenensis*. Total interception did not significantly differ between species, with higher values in *C. magdalenensis* (4.60 mm)> *A. lepidotus* (4.31 mm)> *V. baccifera* (3.63 mm)> *Q. humboldtii* (3.42 mm)> *E. globulus* (1.18 mm) (Table 2). As expected, the highest interception values occurred during the dry season, when canopies are generally dry (Figure 2).




18/11/2021 Wet week
30/11/2020 Wet week
24/01/2021 Dry week
16-17/02/2021 Dry week
21/02/2021 Dry week
28/02/2021 Wet week
Precipitation / Throughfall / Interception (mm)
Stem flow (mm)
Species
P
Al
Cm
Eg
Qh
Tl
Vb

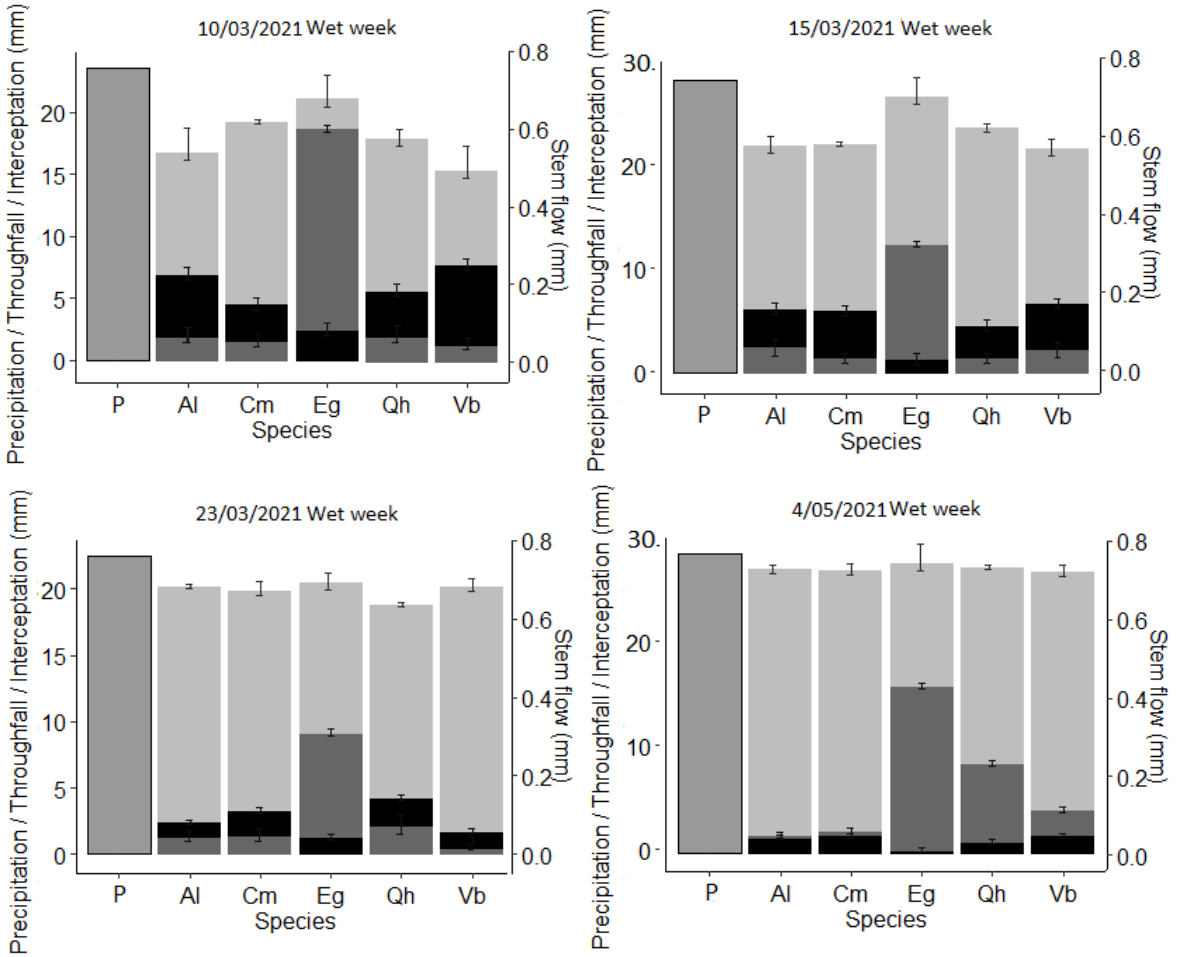


Figure 2. Precipitation partition into 14 events for five scattered tree species *Croton magdalenensis* (Cm), *Andesanthus lepidotus* (Al), *Vismia baccifera* (Vb), and *Quercus humboldtii* (Qh), and *Eucalyptus globulus* (Eg).

Table 2. Mean values of hydrological flow per event (mm) and percentage of each flow in rainfall for five species evaluated (with standard deviation values in parentheses). ([a]) indicate significant differences between *C. magdalenensis* and *E.globulus.*

		Hydrological Flows					
Species	**Precipitation**	**Th**	**I**	**Sf**	**%Th**	**% I**	**%Sf**
C.magdalenensis		20.83 (16.49)	3.80 (1.15)	0.64 (0.08) [a]	82.60(54.41)	15.06(10.23)	2.56 (1.01)
A. lepidotus		20.61 (16.21)	3.66 (1.91)	0.71(0.06)	81.95 (58.22)	15.30 (11.07)	2.82 (1.10)
Q. humboldtii	25.22 (17.24)	21.15 (16.51)	3.43(1.18)	0.67 (0.33)	83.89 (63.50)	13.60 (9.57)	2.67 (0.99)
E. globulus		22.16 (16.61)	1.18 (1.10)	1.68 (0.52) [a]	88.80 (65.80)	4.67 (3.12)	6.68 (2.11)
V. baccifera		20.91(15.18)	3.40(2.12)	0.93(0.21)	82.92 (57.47)	13.49 (9.12)	3.69 (1.54)

3.3 Canopy chemical exchange processes: PO_4-P Concentration.

Although mean concentration of PO_4-P in precipitation was 0.33 mgPO_4-P/l, its most relevant characteristic was its high temporal variation (CV=0.70), particularly associated with its

seasonality. There were changes in the PO_4-P concentration of precipitation when it came into contact with the canopy, in all species (Figure 3a). The highest contributions occurred in events measured in the dry weeks (Figure 3b). The highest concentrations for Th and Sf were observed in *C. magdalenensis* 1.27 mgPO_4-P/l, and 7.01 mgPO_4-P/l. *E. globulus* had the lowest values in the same fluxes 0.32 mgPO_4-P/l and 0.49 mgPO_4-P/l, respectively (Figure 3a). Significant differences ($P<0.05$) were found in PO_4-P concentrations in Sf between *C. magdalenensis* and *E. globulus*.

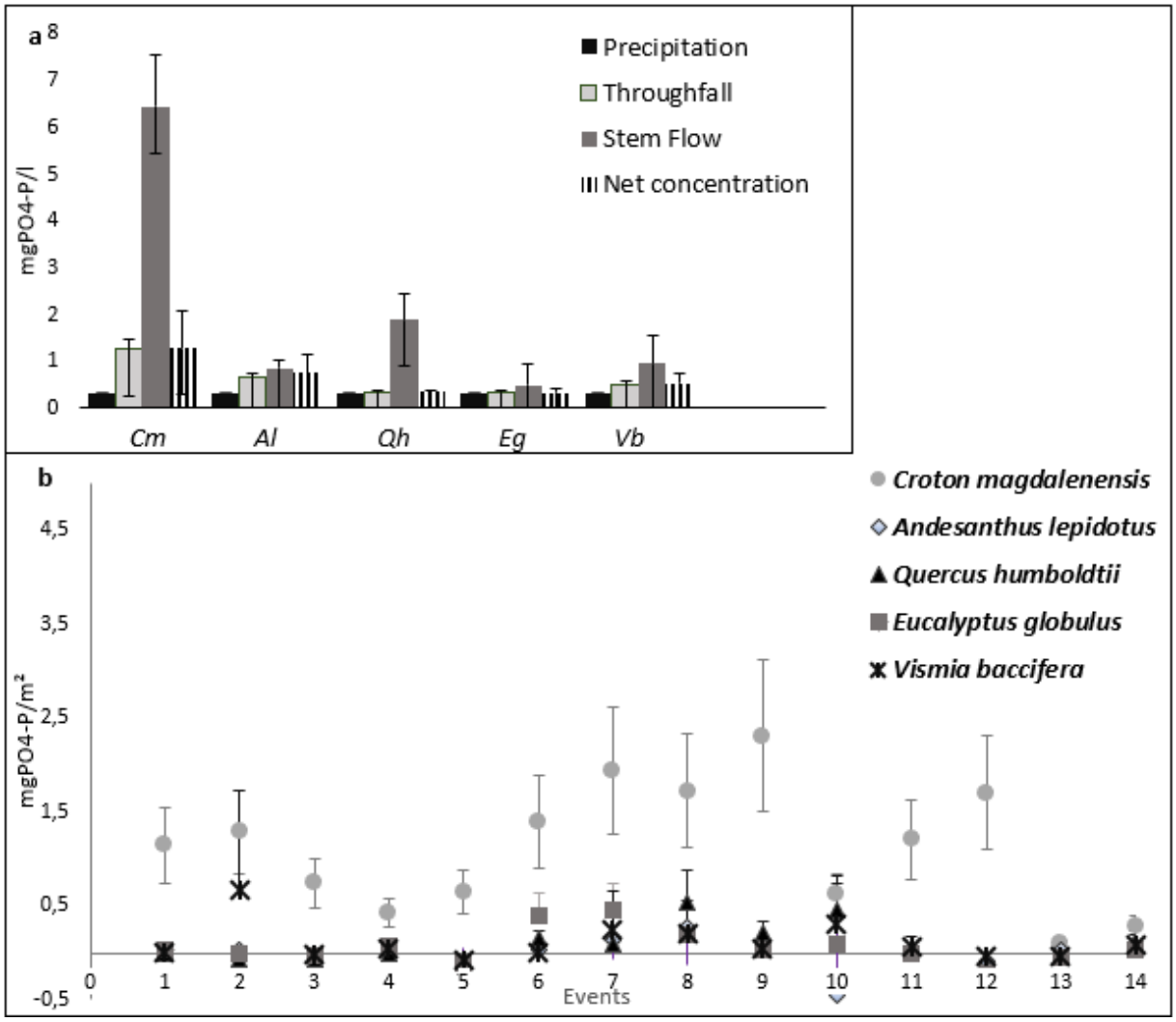


Figure 3 a. Mean concentration PO_4-P in the incoming precipitation (Pi), and Mean volume-weighted concentration in throughfall (Th), stem flow (Sf), net concentration (Nc) b. Temporal variation of PO_4-P in net flow (Nf) for the five species evaluated. Events measured in wet season correspond (1-6) and (10-14), while events measured in dry seasons (7-9). The values shown are means in each species ± standard error of the mean.

Net flux was consistently higher in *C. magdalenensis* 1.09 mgPO_4-P/m², while the other

species had lower values (Figure 3b). *A. lepidotus* had a loss of PO_4-P when the rain came into contact with the canopy in event 10 (Figure 3b). The value of the net concentration (Nc) was higher than precipitation in all species, indicating an enrichment as water passes through the canopy, following the decreasing sequence (although not significantly different): *C. magdalenensis* 1.28 mgPO_4-P/l> *A. lepidotus* 0.75mgPO_4-P/l> *V. baccifera* 0.52mgPO_4-P/l> *Q. humboldtii* 0.35mgPO_4-P/l > *E. globulus* 0.33mgPO_4-P/l (Figure 3a).

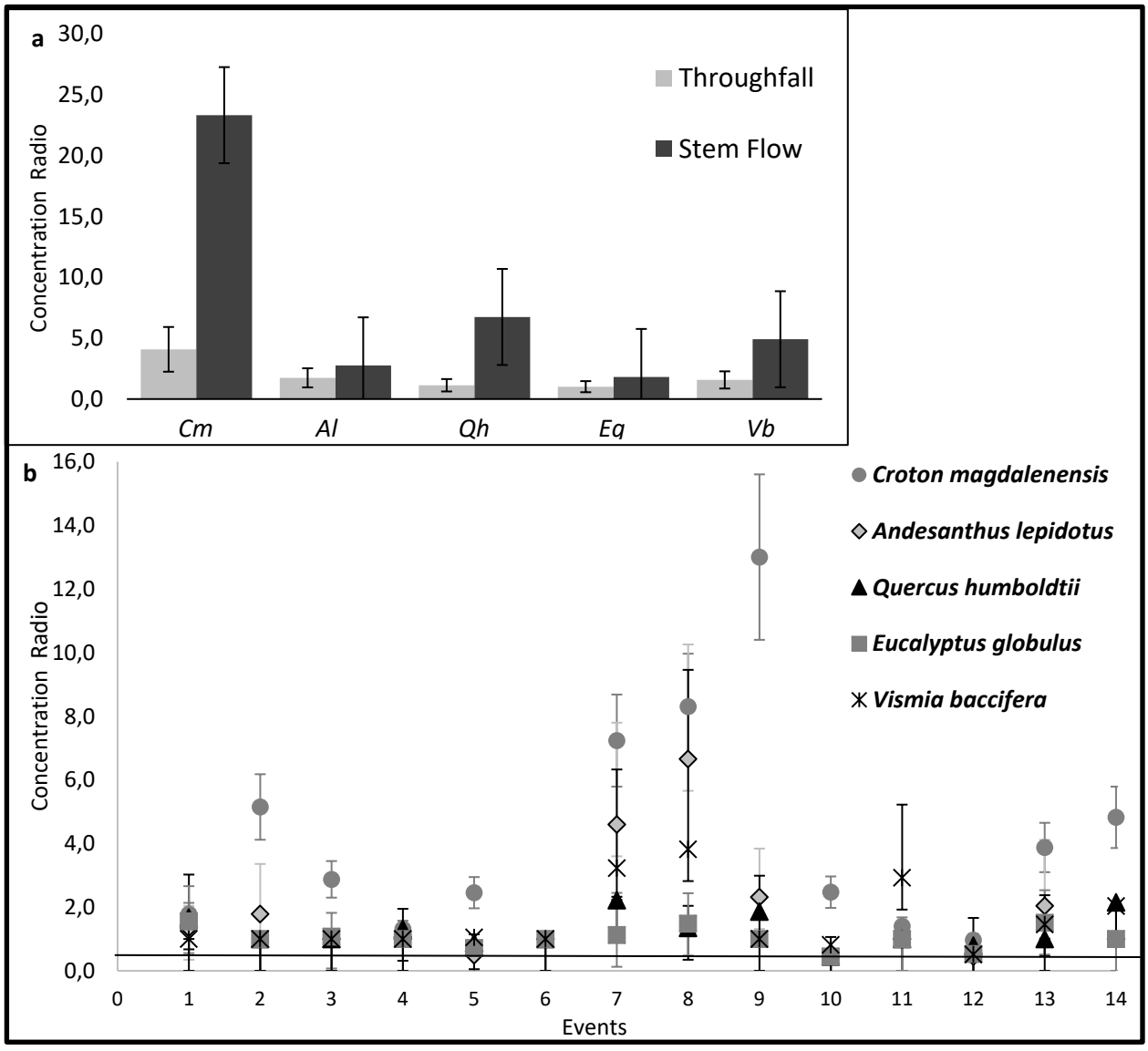


Figure 4 a. Concentration ratio (Cr) for throughfall and stemflow in the differents species evaluated *Croton magdalenensis (Cm), Andesanthus lepidotus (Al), Vismia baccifera (Vb), Quercus humboldtii (Qh) and Eucaliptus globulus (Eg)*. **b**. Temporal variation in Cr-Th in 14 events monitored. The horizontal line represents the unit, reference value for the enrichment or impoverishment in the nutrient concentrations. Events measured in wet season correspond (1-6) and (10-14), while events measured in dry seasons (7-9). The values shown are means in each species ± standard error of the mean.

The highest Cr occurred in native species, with *C. magdalenensis* exhibiting the highest Cr values in both flows (Figure 4a). In most events, there was an enrichment of PO_4-P in *C. magdalenensis* and *V. baccifera* (Cr>1*). Q. humboldtii* and *A. lepidotus* had values (Cr <1) in events (5), (10) and (12), showing a loss of PO_4-P in (Cr-Th) (Figure 4b). *E. globulus* exhibited the lowest values (Cr<1) indicating impoverishment or direct interception of PO_4-P in the canopy. In general, Cr was higher for Sf, in comparison with Th (Figure 4a). Significant differences were found in Cr-Sf between *C. magdalenensis* and *E. globulus* (P<0.05). Generally, (Cr-Th>1) was higher in the events during the dry season where the native species had Cr-Th two to three times higher than in the events measured in the weeks of higher rainfall (Figure 4b).

3.4 Relationship between functional traits and phosphate circulation in scattered trees

We found significant correlations between functional traits and both Cr and Nc (Table 3). In structural traits, epiphyte cover had a significant positive correlation with Nc (P=0.43), Cr-Th (P=0.41), and Cr-Sf (P=0.54). Furthermore, we found significant negative correlations with other structural traits such as crown height in Nc (P=-0.46) and crown area in Nc (P=-0.53), and in Cr-Th (P=-0.44). The foliar traits showed higher correlation coefficients with PO_4-P concentrations (Table 3). In Cr-Th, the highest values are observed in trichome density (P=0.55), and leaf area (P=0.38). Cr-SF had higher correlations with the trichome density (P=0.56), maximum water retention (P=0.43) and leaf area (P=0.41); while Nc has higher correlations whit trichome density (P=0.51) and leaf area (P=0.35).

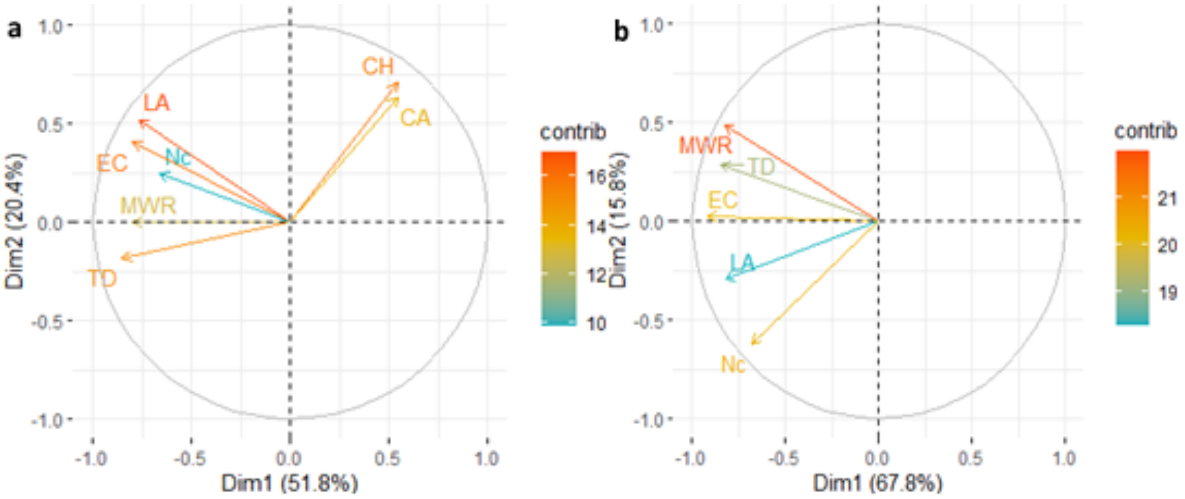
Table 1. Spearman correlation coefficients between net concentration Nc, concentration ratio Cr-Tf and Cr-Sf and plant traits: Crown Height (CH), Crown Area (CA), Crown Density (CD), Density x Volume (DxV), Epiphytes Cover (EC), Text Bark (BT), Diameter (DM), Leaf Area (LA), Specific Leaf Area (SLA), Maximum Water Retention (MWR), Dry Foliar Matter (DFM), Retention Angle (RA), Trichome Density (TD). (P-values in parenthesis), summarized for the 14 rainfall events during 2020 and 2021.

			LEAF TRAITS			
Concentration/Traits	**LA (cm^2)**	**SLA (cm^2/g)**	**MWR (g/cm^2)**	**DFM (mg/g)**	**RA (°)**	**TD**
Th	0.38(0.04)	0.16(0.09)	0.17(0.051)	-0.07(0.76)	-0.20(0.39)	0.55(0.01)
Sf	0.41(0.02)	0.14(0.53)	0.43(0.05)	-0.38(0.09)	-0.48(0.12)	0.56(0.009)
Nc	0.35(0.02)	-0.009(0.96)	0.15(0.052)	0.15(0.57)	-0.35(0.12)	0.51(0.01)

			STRUCTURAL TRAITS				
Concentration/Traits	**CH(m)**	**CA (m^2)**	**CD (%)**	**DxV**	**EC (cm^2)**	**BT**	**DM(m)**
TH	-0.25(0.61)	-0.44 (0.05)	-0.28(0.21)	-0.50(0.06)	0.41(0.02)	0.37(0.10)	-0.23(0.31)

SF	-0.12(0.43)	-0.34 (0.13)	0.10(0.67)	-0.31(0.17)	0.54 (0.008)	0.15(0.06)	-0.32(0.12)
Nc	-0.46(0.03)	-0.53(0.01)	-0.16(0.48)	-0.26(0.07)	0.43 (0.01)	0.28(0.22)	-0.41(0.07)

When considering the relationship between functional traits with significant relationships and Nc (PCA in figure 5a), we found that 72.2% of the total variance is explained in the first two components. The traits with the highest contribution to the first component were epiphyte cover (-0.331), and trichome density (0.328). In the second component, the leaf area (0.361) and maximum water retention (-0.323) with the highest contributions and show the same direction as Nc, while the area and height of the crown show directions contrary to the Nc of PO_4-P (figure 5a), and have the least explanations. (PCA in figure 5b) accumulated 83.60% of the variance in the first two components, the variables with the highest contribution to the first component are epiphyte cover (-0.435) and trichomes density (-0.429). In the second component, leaf area (0.548) and maximum water retention (-0.338) represent the highest contribution. In Cr-Th (figure 5c), the total variance explained in the first two components is 80.5%. Epiphyte cover (-0.485) and trichomes density (-0.469), the traits with the highest contribution to the first component; in the second component, leaf area (0.558) had the highest contribution. Leaf area shows the same direction as Nc and Cr-Th (figure 5b, Figure 5c). For Cr-Sf (figure 5d) the first two components explained 82.3% of the variance. Traits with the highest contribution to the first component were epiphyte cover (-0.505) and trichome density (-0.465) and in the second component maximum water retention (0.51), where epiphyte coverage and leaf area show the same direction as Cr-Sf (figure 5d).



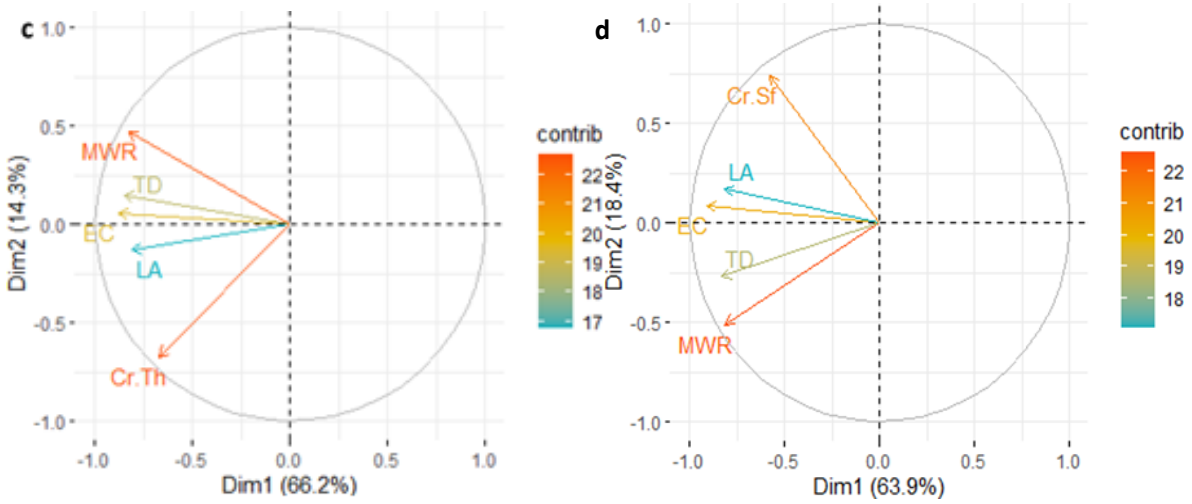


Figure 5 Principal component analysis (PCA) between the significant relationships of functional traits with net concentrations (Nc) and concentration ratios (Cr-Th), (Cr-Sf). **a**. PCA between Nc and all functional traits that presented significant relationships Crown height (CH), Crown Area (CA), Epiphytes Cover (EC), Leaf Area (LA), Maximum Water Retention (MWR), Trichome Density (TD). **b**. PCA between Nc and functional traits that presented significant positive relationships Epiphytes Cover (EC), Leaf Area (LA), Maximum Water Retention (MWR), Trichome Density (TD). **c**. PCA between Cr-Th and functional traits that presented significant positive relationships Epiphytes Cover (EC), Leaf Area (LA), Maximum Water Retention (MWR), Trichome Density (TD), **d**. PCA between Cr-Sf and functional traits that presented significant positive relationships Epiphytes Cover (EC), Leaf Area (LA), Maximum Water Retention (MWR), Trichome Density (TD).

3.5 General patterns of functional traits and phosphate circulation on individual trees

Individuals were divided into three groups based on the best cophenetic coefficient (Table 4) through 4 different combinations (Figure 6), associated with their configuration of traits and concentrations of PO_4-P. In (Figure 6a), individuals of the species *C. magdalenesis* form group 1, where the highest concentrations of PO_4-P occur, and also characteristic functional traits such as higher epiphyte load, foliar area, and trichome density. These functional traits have the highest relationship with PO_4-P concentrations (Table 3). Group 2, whit the highest number of individuals, included three native species *A. lepidotus*, *V. baccifera*, and *Q. humboldtii.* Individuals with the highest values in structural traits such as height and crown area form group 3, dominated by the species *E. globulus*, which coincided whit the lowest concentrations of PO_4-P.

Individuals of *C. magdalenensis* formed a separate group based on their highest concentrations of PO_4-P in Nc and Cr-Th (Figure 6a, Figure 6b, Figure 6c). The individuals of *A. lepidotus* form a differential group with respect to the rest of the species, while the individuals of *V. baccifera, Q. humboldtii*, and *E. globulus* were grouped and associated with lower concentrations of PO_4-P. *C. magdalenensis* presented differential concentrations with

respect to the rest of the species in Cr-Sf (Figure 6d).

Table 4. Cophenetic coefficients determined for different methods and distances in cluster analysis

Distances/Methods	Average	Ward	Mcquitty
Euclidean	0.995	0.882	0.993
Manhattan	0.943	0.887	**0.996**
Minkowski	0.912	0.882	0.994

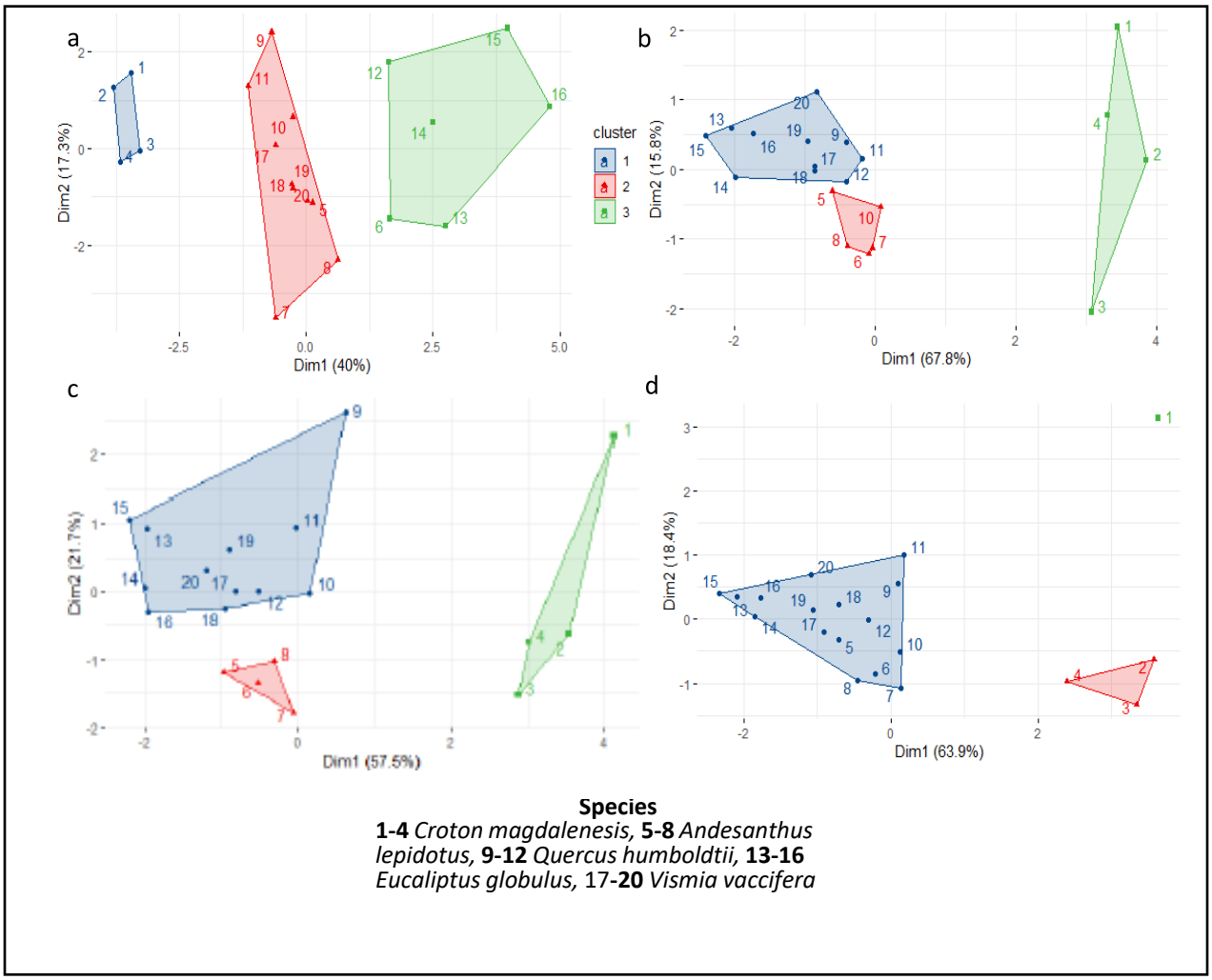


Figure 6. Groups formed between the evaluated species associated with the combinations of functional traits and PO_4-P concentrations **a**. Nc and 12 traits measured **b**. Nc and traits that presented greater relationships: Epiphytes Cover (EC), Leaf Area (LA), Maximum Water Retention (MWR), Trichome Density (TD). **c**. Cr-Th and traits that presented the higher relationships **d**. Cr-Sf and traits that presented the higher relationships.

3.6 Concentration ratio and net concentration of PO_4-P in relation to rainfall and meteorological characteristics.

There was a wide range of variation in the meteorological characteristic of monitored rainfall events (Appendix 1). Notably, rainfall characteristics (total amount, intensity) as well as dry spell length (antecedent dry days) varied among events. When related to PO_4-P circulation, we found that the highest significant positive relationships occurred between Dry Spells (Ds) with Nc (P=0.38), Cr-Th (0.35) and Cr-Sf (0.43) (Table 5). In addition, negative relationships Nc (P=-0.27) and Cr-Sf (P=-0.19), Cr-Th exhibited a significant negative relationship with total rain (P=-0.33) (Table 5).

Table 5. Spearman correlation analysis between meteorological and hydrological variables: temperature (T), Humidity (H), Wind velocity (WV), Total Rain (TR), Intensity (Int), Duration (Dr), and Dry spell (Ds), whit net concentration (Nc), concentration ratio in stem flow (Cr-Sf) and throughfall (Cr-Th). Summarized for the 14 rainfall events during 2020 and 2021 (P-values in parenthesis).

	METEOROLOGICAL AND HYDROLOGICAL VARIABLES						
	T (°)	H (%)	WV (m/s)	TR (mm)	Int (mm/h)	Dr (h)	Ds (days)
Nc	0.44(0.60)	0.22(0.12)	0.3(0.32)	-0.50(0.07)	-0.27(0.01)	0.27(0.36)	0.38(0.06)
Th	-0.19(0.52)	0.22(0.47)	0.36(0.21)	-0.33(0.04)	-0.34(0.70)	0.22(0.78)	0.35(0.03)
SF	-0.19(0.65)	0.03(0.90)	0.22(0.45)	-0.31(0.45)	-0.19(0.041)	-0.32(0.88)	0.47(0.05)

4. Discussion

4.1 Functional traits and their effect on precipitation partitioning

Our results show interspecific differences in the hydrological fluxes evaluated in scattered trees characteristic of modified mountain ecosystems in the northern Andes (Figure 2). Particularly, in the exotic species *E. globulus* exhibited the highest volumes in Th and Sf, with a higher contribution of water to the soil (Table 2). This occurs as a result of higher values in the crown area and height; (Table 1), which have been related to higher volumes of water in both Th and Sf for different species of trees in the tropics (Yue et al., 2021). Notably, our results highlight the role of native species in water interception (Table 2) due to differences in the structure of the canopy, the texture of the rougher bark, and a high presence of epiphytes (Table 1). Depending on their structure, abundance, and diversity of species, epiphytes are the largest water reservoir (Porada et al., 2018). Our results suggest that the characteristics of the composition and structure of scattered trees in tropical Andean ecosystems may have a positive effect on the local dynamics of the water reaching the soil, with potential effects on the reduction of evaporation and the maintenance of the moisture in

the topsoil, as evidenced in other tree species scattered in open areas of the tropics (Benegas et al., 2021) process that potentially favoring biogeochemical exchange (Van Stan & Pypker, 2015).

Th and Sf values obtained in the five species are close to the global average value for scattered trees from tropical regions (Junqueira Junior et al., 2019) (Nytch et al., 2019) (Alves et al., 2018). That they have the potential to recharge groundwater (Ilstedt et al., 2016), which during the dry season can serve as a source of water for grasses and trees due to surface limitations (Benegas et al., 2021). However, we recognize that the exotic species *E globulus* with higher water demands (Cardelús et al., 2020), may present different responses regarding the general water balance in these open landscapes. As expected, Sf values were low, and this did not represent a significant contribution to the water that arrives in the soil, with lower values in species *C. magdalenesis* and *A. lepidoptus* (Appendix 3), in events measured in dry weeks (Figure 2). The significant difference between *E. globulus* and *C. magdalenesis* in this flow demonstrates how potentially the composition of individual traits affects hydrological regulation at the landscape scale. That are associated with higher retention of water in the canopy conditioned by architecture, the highest epiphyte cover, higher leaf area (Table 2), and the hydrological characteristics and meteorological of the storm (Ponette-González, Alexandra G. Van Stan II et al., 2020).

4.2 PO_4-P circulation in scattered trees

Our results show differences in PO_4-P circulation and concentration in the scattered tree species and between hydrological events, with higher average concentrations of PO_4-P in Th and Sf than in incoming precipitation (Figure 3). In general, the water is enriched with PO_4-P when it comes into contact with the canopy, increasing the concentration of the flows reaching the soil, as highlighted by previous studies in natural forests in the Andes (León-Peláez et al., 2020; Suescún et al., 2021). As expected, Sf had the highest concentrations of PO4-P (Figure 3), potentially associated with higher contact and residence time of water with the tree surfaces. In contrast, although lower in concentration, the overall contribution of PO_4-P in Th is higher (Figure 3) and potentially more important contributor to soil fertility than Sf and bulk precipitation (Levia et al., 2019). In fact, the concentrations of PO_4-P that reach the soil surface in the different species are low and similar to those reported by other

studies in tropical Andean ecosystems (Wilcke et al., 2019; Suescún et al., 2021). In scattered trees, the overall canopy exchange processes are influenced by atmospheric inputs, functional traits, and interactions between raindrops and the leaf surface that determine the exchange of PO_4-P in the canopy through leaching (Goll et al., 2017).

Our results indicate that the native scattered species have a higher Nc and Cr than the exotic species (Figure 3, Figure 4). This highlights their potential for maintaining key-ecosystem services such as nutrient regulation and maintenance of soil fertility. Differences between native and exotic species can be associated with canopy structure, bark roughness, and higher epiphyte cover (Table 1), as well as key foliar traits related with highly diverse Andean ecosystems (Asner et al., 2014). That influences the deposition, accumulation, flow, and enrichment of aerosols and solute on the canopy surfaces (Van Stan et al., 2016; Su et al., 2019). However, deposition varies greatly among rainfall events potentially in response to factors such as is highly variable, so the differences in the amounts of PO_4-P obtained in the study can be influenced by multiple patterns such as Pollen that represent a significant potential source of P (Bigio & Angert, 2018), deposition of P-rich dust from agricultural and urban environments (Du et al., 2016), microbial biomass (Maoela et al., 2019), and previous soil fertilization that can affect leaf leaching (Vanden Nest et al., 2014). These biogeochemical drivers determine the temporal and spatial variability in the circulation of PO_4-P in Th and Sf.

4.3 Functional traits and phosphate circulation

Our results suggest that the variations in the morphology and composition of each individual determine the hydrological behavior, the quantity, and concentration of PO_4-P that reach the soil in modified Andean ecosystems (Figure 5). Scattered trees with a combination of functional traits characterized like higher epiphyte cover, higher leaf area, and higher trichome density exhibit the highest concentrations of PO_4-P (Table 3). Foliar traits are decisive in P circulation, by contributing to the enrichment of Th and Sf, or by limiting the loss of P in conditions of low availability in the soil (Wang & Lambers, 2020). Additionally, larger leaf area and presence of trichomes can increase the surface area of capture, atmospheric deposition, and the interception of dust and other particles that move through

the air masses of the canopy that can later be deposited in the surface (Bickford, 2016), increasing the internal circulation of nutrients (Weerakkody et al., 2018). As expected, our results show higher Nc of PO_4-P in individuals with greater epiphyte or bryophyte cover in stems and branches (Table 3), due to the capacity that epiphytes have to lead differences in the absorption, retention, acquisition, and enrichment of nutrients (Van Stan & Pypker, 2015; Porada et al., 2018) Associated with its determining functional traits in the amount of PO_4-P uptake (Winkler & Zotz, 2009).

4.4 Meteorological and precipitation characteristics and their relationship with PO_4-P concentrations

The highest concentrations of PO_4-P that arrived in soil were observed in the events occurring in dry weeks (Figure 3), where the number of antecedent dry days showed significant relationships with the Nc and Cr during the observation period (Table 5); potentially, due to longer accumulation time for aerosols in plant surfaces, increase the concentrations of PO_4-P before they are deposited in the soil (Violaki et al., 2018). Conversely, events measured during rainy periods showed the lowest concentrations of PO_4-P (Figure 3), due to that the higher frequency of rains and higher volumes of water diluting matter suspended in the atmosphere and the particles suspended on the surface of the plants (Homeier et al., 2012).

Consequently, our results agree with previous studies that have shown higher solute concentrations because leaching, washing, and canopy exchange are higher at the beginning of a storm (Van Stan et al., 2016), while higher rainfall events can result in dilution of solutes. Other studies suggest a possible seasonal effect on the capture of P, where more prolonged and severe dry seasons determine high retention of P in the canopy (Wilcke et al., 2019), which could exacerbate in tropical Andean ecosystems with natural limitations of PO_4-P in the soil (Suescún et al., 2017).

5. Conclusion

Our results indicate that the interception and circulation of precipitation in scattered trees is an important input of limiting nutrients such as PO_4-P in modified ecosystems, where the internal cycle of PO_4-P in trees allows the enrichment of the fluxes of Th and Sf that reach

the soil when water comes into contact with aerial surfaces such as leaves, bark, and epiphytes. Consequently, the hydrological behavior and the circulation of PO_4-P in scattered trees respond to a configuration of specific traits such as higher epiphyte load, foliar area, and trichome density, which affect the concentrations of PO_4-P that reach the soil in individual trees. More generally, our results indicate that the crowns of scattered trees influence the availability of PO_4-P as a function of the amount and chemical composition of rain, which is highly sensitive to global environmental change and is decisive in the functioning of ecosystems.

Our results are particularly relevant given that the highest contributions of PO_4-P to the soil occur in native scattered species, which become key structures in the recovery of fragmented Andean ecosystems, due to their greater capacity in circulation and deposition of PO_4-P. We highlight the role of the species *C. magdalenensis*, a pioneer species that generally dominates early forest recovery in disturbed areas and behaves as a PO_4-P hotspot in modified landscapes in the mountainous region of central Colombia. Notably, our results indicate a significant difference between native exotic species, highlighting the need for careful selection of species in restoration processes. Overall, our results highlight the complex biogeochemical interactions that occur in these highly biodiverse ecosystems where plant functional traits can be useful to describe ecosystem function at the landscape scale.

Our results show that scattered trees in fragmented landscapes of the tropical Andes can potentially transport phosphate to the soil, helping to reestablish biogeochemical processes related to limiting nutrients (such as Phosphorus), which must be prioritized, particularly in the early stages of the restoration of degraded ecosystems. In addition, our results can contribute to the development of management strategies in ecosystems in the mountainous region from central Colombia, highlighting how functional traits can help the selection of species that help in the reactivation of processes. such as the circulation of limiting nutrients, which can contribute to soil fertility and allow natural regeneration of the functions of the ecosystem.

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7. Appendix

Appendix 1. Functional traits measurement protocol.

Leaf Traits	**Measurement protocol**
Leaf area (cm^2)	10 leaf were taken from each individual and scanned with an Epson L3210 scanner. With the Image J program, the area of the leaf blade projected by each sample was determined. The average value of the leaves in each individual was determined as the leaf area.
Specific leaf area (cm^2/g)	10 leaf were taken from each individual and the area in each of the leaves was determined. The samples were dried in the oven at 60 °C for 72 h. Each leaf was weighed individually and divided by the leaf area. The average value of leaves in each individual was determined as the specific leaf area.
Retention angle (°)	Seven leaf were taken from each individual and, each leaf was held by the petiole five drops were dropped using dosing droppers with an outlet diameter of 3.50 mm. This droplet size is within the ranges in precipitation in the region (Ladino Rincon, 2017). The drops were released from a height of 50 cm avoiding splashing. The angle that the blade makes with the horizontal was determined using the Tracker program. The average angle of the seven leaves was determined as the retention angle in each

	individual.
Dry matter foliar (mg/g)	Seven leaf were taken for each individual and weighed individually on a precision balance of 0.01 g. Each sample was dried in an oven at 60 ° C for 72 h and recorded as dry mass (Pérez-Harguindeguy et al., 2003). It was divided between the dry mass in the oven and the fresh mass in each sample. The average between the seven leaves per individual was determined as the dry foliage area.
Trichome density (%)	10 leaf were taken for each individual, and a section was cut in each leaf, avoiding including the main veins and the leaf edges. Each section of the leaf was immersed in sodium hypochlorite - 48 hours at room temperature, until the epidermis separated from the mesophyll, each sample was washed with distilled water and immersed in methylene blue. Then, it is observed under a digital microscope at 40X magnification, taking photographs of each sample. The percentage of trichome coverage in each photograph was determined using Image J software.
Maximum water retention (g/cm²)	Seven leaf were taken for each individual and weighed on a precision balance of 0.01 g. Each leaf was sprayed with an atomizer until completely wetted and weighed to determine the maximum water retained on the surface (g), later it was divided by the area of the leaf (cm²) in each individual. The leaves were considered dry when they reached their original fresh weight.

Structural traits	**Measurement protocol**
Crown height (m)	It is determined as the vertical distance from the highest point of growth to the lowest point of live canopy foliage.
Crown area (m²)	The major axis and the minor axis of the cup were measured with a line on each individual. From the measured axes, the area of the crown was calculated with the formula for the area of an ellipse.
Crown density (%)	Photographs were taken under the crown of each individual in the four cardinal points, 1.30 m high with the front camera of the cell phone. Subsequently, the images were processed in the Image J program, in which they were converted to a binary image, and the percentage of area in black color (foliage) was measured.
DxV	Product between the density and the volume of the crown. The volume is calculated assuming that the crown of a tree resembles a cylindrical shape.
Epiphyte cover (%)	Four photographs were taken facing the trunk in the direction of the 4 cardinal points at 1.30 m in height in an area of 30 * 60 of the main trunk in each individual. The percentage of epiphyte coverage was estimated using the ARLIQ software in each of the photographs and the average per individual was determined.
Text bark	Photographs of the bark were taken on the four faces of the trunk of five individuals per species. The photograph was taken at a height of 1.30 m and at a distance of 7 cm from the lens. The photographs were processed with the Image J program, using the GLCM texture analyzer plug-in.

Appendix 2. Precipitation events and mean values of the meteorological and hydrological characteristics

monitored in the study period.

Event	Date	Temperature (°c)	Humidity (%)	Wind speed (km/h)	Total Rain (mm)	Intensity (mm/h)	Duration (h)	Dry Spell (days)
1	6/10/2020	11.34	96.57	0.05	20.72	5.92	3.5	1
2	28/10/2020	13.06	96.52	0.06	28.45	9.48	3	3
3	4/11/2020	12.40	97.14	0.05	28.30	11.32	2.5	2
4	10/11/2020	11.25	97.16	0.35	15.72	5.24	3	2
5	18/11/2020	13.62	95.03	0.26	17.29	4.94	3.5	1
6	30/11/2020	13.72	96.28	0.54	28.30	8.08	3.5	2
7	24/01/2021	11.88	97.46	0.04	7.54	1.50	5	12
8	16-17/02/2021	11.78	95.85	0.11	10.3	2.69	3.5	2
9	21/02/2021	10.34	98.76	0.08	20.08	8.03	2.5	2
10	28/02/2021	-	-	-	80.4	-	-	4
11	10/03/2021	12.5	95.5	0.17	23.58	6.73	3.5	1
12	15/03/2021	9.97	86.3	0.08	24.15	5.36	4.5	2
13	23/03/2021	11.27	86	0.02	22.52	7.50	3	1
14	4/05/2021	10.9	86	0.17	25.67	6.41	4	1

Appendix 3. Percentage values with respect to the partition of the precipitation in Th, Sf and the interception in each event.

Event 1	P	%TH	%Sf	% Int	Event 8	P	%TH	%Sf	% Int
C.M	20,72	87,63	0,10	12, 19	C.M	9,43	75,00	0,03	24,97
A.L		85,32	0,39	14,31	A.L		78,67	0,04	21,29
Q.H		89,74	0,26	10, 01	Q.H		68,93	0,03	31,04
E.G		97,02	1,76	1,76	E.G		83,33	0,30	16,36
V.B		92,41	0,22	7, 37	V.B		72,57	0,04	26,79
Event 2	P	%TH	%Sf	% Int	Event 9	P	%TH	%Sf	% Int
C.M	28,46	85,64	0,15	14,28	C.M	20,08	79,17	0,02	20,81
A.L		79,66	0,33	20,21	A.L		78,30	0,03	21,67

Q.H		86,50	0,27	13,63	Q.H		69,86	0,02	30,11
E.G		91,87	2,10	6,03	E.G		91,61	0,21	8,19
V.B		80,40	0,17	21,99	V.B		82,21	0,07	17,72
Event 3	P	%TH	%Sf	% Int	Event 10	P	%TH	%Sf	% Int
C.M	28,30	85,81	0,13	14,06	C.M	80,41	90,47	0,40	9,13
A.L		86,09	0,43	13,52	A.L		87,18	0,30	12,52
Q.H		84,06	0,21	16,08	Q.H		88,33	1,52	10,16
E.G		91,68	2,76	5,09	E.G		93,81	2,13	4,05
V.B		83,08	0,06	16,87	V.B		86,57	0,24	13,19
Event 4	P	%TH	%Sf	%int	Event 11	P	%TH	%Sf	% Int
C.M	15,72	78,25	0,10	21,65	C.M	23,58	81,73	0,02	18,77
A.L		76,25	0,31	23,44	A.L		84,01	0,08	16,43
Q.H		80,78	0,09	19,91	Q.H		85,01	0,13	14,86
E.G		91,89	2,91	5,30	E.G		93,18	0,78	6,05
V.B		76,25	0,21	23,54	V.B		85,84	0,09	14,07
Event 5	P	%TH	%Sf	%int	Event 12	P	%TH	%Sf	% Int
C.M	17,30	78,41	0,03	21,56	C.M	28,15	84,20	0,12	16,58
A.L		81,73	0,07	18,42	A.L		90,75	0,37	8,88
Q.H		82,32	0,04	17,65	Q.H		82,91	0,17	16,92
E.G		93,64	0,15	6,21	E.G		94,94	2,18	2,88
V.B		86,36	0,03	13,61	V.B		86,75	0,17	13,08

Event 6	P	%TH	%Sf	%int	Event 13	P	%TH	%Sf	% Int
C.M	28,30	84,44	0,11	15,45	C.M	22,53	85,50	0,11	14,39
A.L		85,54	0,26	14,20	A.L		89,25	0,42	10,33
Q.H		85,09	0,27	14,64	Q.H		83,20	0,38	16,41
E.G		94,98	1,59	3,44	E.G		89,52	2,01	8,47
V.B		83,99	0,14	15,87	V.B		92,48	0,20	7,32
Event 7	P	%TH	%Sf	%int	Event 14	P	%TH	%Sf	% Int
C.M	7,56	77,99	0,03	21,98	C.M	27,45	84,53	0,18	15,91
A.L		75,63	0,10	24,27	A.L		77,42	0,13	21,04
Q.H		74,67	0,04	25,29	Q.H		86,49	0,16	13,62
E.G		90,78	0,20	9,02	E.G		90,07	2,09	6,02

V.B	80,79	0,07	19,14	V.B	79,26	0,23	22,58	