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Authors: Hoyos-Gómez, Saúl E., and Bernal, Rodrigo

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Rheophytes of the Samaná Norte River, Colombia: A Hydroelectric Project Threatens an Endemic Flora

Saúl E. Hoyos-Gómez[1] and Rodrigo Bernal[2]

Abstract

We studied the rheophytic vascular flora of the Samaná Norte River basin in Antioquia, Colombia, by rafting along a 61.4-km stretch of the river and establishing 10 plots on its banks. We found 58 species of rheophytes, including morphospecies, belonging to 29 families, mostly herbs and subshrubs. At least nine of the species are known only from this river basin and seven of them were discovered as new to science during this study. The nine species endemic to this river basin have estimated area of occupancy smaller than 10 km^2 and are here categorized as critically endangered. We recommend reconsidering plans to dam the river for a hydroelectric plant, as it might reduce populations of the nine critically endangered species and might drive at least two of them to extinction.

Keywords

Andes, dam, hydroelectric power, rheophytes, threatened plants

Introduction

Rheophytes are plants that grow along the margins of swift water currents or sometimes on the streambed or on its rocks (van Steenis, 1981, 1987). They have adapted to withstand the force of water, thus taking advantage of an extreme environment that is not suitable for most organisms. To do this, rheophytes have developed particular traits in their architecture, roots, leaves, flowers, and fruits, which facilitate their resistance to the strong currents and the establishment of the species in new sites. One of the most obvious adaptations of rheophytes is the narrow, streamlined leaf profile, which minimizes damage or uprooting by the current (Ameka, Adomako, De Graft-Johnson, Cheek, & Swaine, 1996; Bernardes, 2012; Köhler, Bernardes, & Brack, 2016; van Steenis, 1981, 1987).

Rheophytes occur worldwide among at least 125 families of vascular plants and ca. 1,000 species are known to have this growth form. However, this figure, compiled from available studies, is most likely an underestimate, as studies of rheophytic floras are scarce, probably due to the difficulties inherent to exploring their habitat. In the Western Hemisphere, for example, we are aware of just three studies of rheophytic floras or communities (Fontana, 2001; Klein, 1979; Köhler et al., 2016). Most accounts of rheophytic plants in this area include discussions of individual plants, sometimes described as new to science (e.g., Bernal, Hoyos-Gómez, & Borchsenius, 2017; Berry & Olson, 1998; Galeano-Garcés & Skov, 1989; Gonçalves & Arruda, 2013; Hassemer & Rønsted, 2016).

Many rheophytic species are endemic to small areas, sometimes even to a single river (van Steenis, 1981, 1987), and they are useful indicators of river health (Ameka et al., 1996). Furthermore, due to their particular habitat, they are the first species to become locally extinct when a river is dammed. However, rheophytes are often disregarded in the environmental impact studies made for planning dams (e.g., Integral, 2012).

[1]Universidad de Antioquia, Medellín, Colombia
[2]Jardín Botánico del Quindío, Calarcá, Quindío, Colombia

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Corresponding Author:
Rodrigo Bernal, Jardín Botánico del Quindío, Avenida Centenario #15-190, Calarcá 0001, Colombia.
Email: rgbernalg@gmail.com

A dam for a hydroelectric plant is planned to flood a big tract of the Samaná Norte River, a large Andean stream that flows on the eastern slopes of the Central Cordillera of Colombia, in the Department of Antioquia. This river flows into the Nare River, a tributary of the Magdalena River, the largest one in Andean Colombia. The Samaná Norte river flows through steep, mostly forested slopes that make up a canyon ca. 40 km long. The numerous strong rapids along the course, combined with the steep slopes, have prevented heavy deforestation along its margins and have kept the rocky banks mostly pristine.

The Samaná Norte River drains a basin ca. 2,700 km^2 (Figure 1), mostly comprising wet to moist tropical and premontane forest. The river bed has an average slope of 0.5% and an average width of just 30 m. Because of this, the stream has a strong, fast current (0.8 to 2.4 m/s on average) and short floods up to 15 m above the average level, during which stream speed is even higher. These factors, combined with the geologic nature of the area, which includes karstic formations resulting from the marble intrusions that cut the lower portion of the canyon, make up a landscape of rocky margins, including steep walls, large boulders, and small stony beaches (Figure 2). These formations harbor a rich community of rheophytic plants, adapted to the fast stream and the frequent floods (Figure 3).

Plans to dam the Samaná Norte River are underway, and a license has been already granted to the interested firm by the Colombian Environmental Licensing Agency (ANLA), based on a study of the environmental impact of the dam (Integral, 2012). This study mentions only four species of rheophytes in the area (not recognized as such), as the study of this group of organisms can hardly be made by sampling from land (as researchers did for that study), due to the depth of the canyon, its steep slopes, and the rocky nature of the margins. On the other hand, due to the swift stream of the river and its numerous and dangerous rapids, exploring the margins from the river is a risky adventure that so far had not been tackled by botanists.

A rheophytic palm was recently discovered in the river (Bernal et al., 2017), and many other rheophytic species were found during four expeditions along the canyon. Because of this, we decided to investigate in more detail the rheophytic flora of the Samaná Norte River, in order to assess the impact that the proposed damming would have on the conservation of the species involved. In particular, we studied the distribution, frequency, abundance, level of occupancy, and preferred substrate of

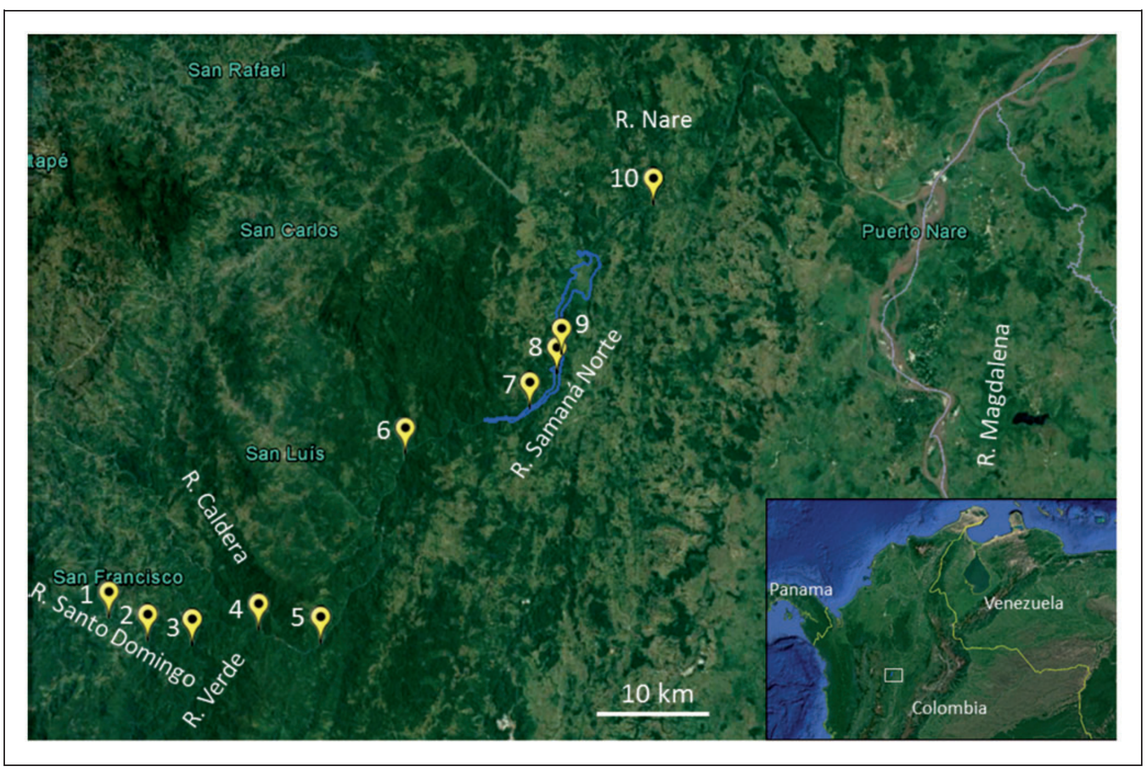

Figure 1. Location of the Samaná Norte River basin, Antioquia, Colombia. The blue line marks the flood level of the planned Porvenir II dam. Yellow marks indicate plot sites for this study.

Figure 2. View of the Samaná Norte River, Antioquia, Colombia. This area would be 60 m under water, if the hydroelectric project Porvenir II were developed. Photo: Rodrigo Bernal.

each of the rheophytes. These parameters will be vital for refining the information of the project's environmental impact study, which did not include this critical group of plants.

Methods

We documented the occurrence of rheophytes during three initial expeditions along the river, in a 31-km tract from the bridge on the Medellín-Bogotá highway, downstream to the discharge zone of the Punchiná-Guatapé reservoir system. After an initial set of species was properly documented and identified, we made a detailed survey along a 61.4-km long tract of the basin, from the confluence of the Santo Domingo and Melcocho rivers (5°56'12.05'' N, 75° 6'30.76'' W, 578 m elevation), down to the confluence of the Samaná Norte and the Nare Rivers (6°12'20.28'' N, 74°45'22.66'' W, 167 m elevation).

We explored the rheophytes by rafting along the river and establishing 10 plots 20-m long along the river (Figure 1). At each plot, we recorded all species from water level up to the upper flood level. This option was deemed better than establishing fixed-area plots, as the reach of flooding is different at each point, depending on the physiography. At each plot, we recorded for each species its presence or absence, abundance, level of occupancy above the river level, and kind of substrate where the plant grew.

Abundance was measured in a subjective scale from 1 to 5 (rare, occasional, frequent, common, and abundant). Each researcher independently assigned a value to each species, and the final value was calculated as the average of the two individual values. Overall abundance was calculated as the sum of the species' abundance at each of the 10 plots, and thus it can range from 0 (absent from all plots) to 50 (occurring at all plots, with abundance 5 at each). The level of occupancy was recorded in a visual scale that divides the usual range of the river's flash floods at each plot into three regions: lower, intermediate, and high. The kind of substrate was recorded as rock, wall, or sand.

Besides the plots, we explored every rheophytic species spotted from the boat, and collected every species found that was not previously recorded in the plots, including Podostemaceae growing on rocks in the middle of the river. Vouchers of each species were collected and deposited at HUA, COL, or FMB. For most species,

Figure 3. Aspect of a rheophytic community on rocky margins of the Samaná Norte River, Antioquia, Colombia.

identifications were made by specialists (see Acknowledgments). Some of the species that remain unidentified (e.g., *Cestrum* sp., *Eugenia* sp., *Marathrum* spp., *Nectandra* sp.) represent difficult taxa currently under study by specialists, and some of them may prove to represent additional new species. Other species (like some *Marathrum* spp.) are represented by incomplete material that makes proper identifications impossible.

Based on their distribution along the river, as documented from our plots and observations, we calculated the estimated area of occupancy (EAO) of the endemic species and assessed their conservation status according to International Union for Conservation of Nature (IUCN) parameters (IUCN, 2017).

Results

We found 58 species of rheophytic vascular plants along the 61.4-km tract of the Samaná Norte River basin (Table 1). They belong to 29 families, and include 48 species of flowering plants, 8 species of pteridophytes, and 2 species of lycophytes. Some taxa, particularly in Podostemaceae and Primulaceae, have not been identified at species level, and they are presented as morphospecies. The most diverse families were Acanthaceae (six species), Melastomataceae (five species), and Podostemaceae (five species).

There were only two species that occurred at all sampling sites—the fern *Thelypteris chocoen*sis A.R. Sm. & Lellinger and the cyclanth *Dicranopygium goudotii* Harl. Both species were also the most abundant taxa at the majority of sites (Table 1). The next most common species was an undescribed species of *Piper* L., which occurred at nine sites and ranked third in overall abundance. On the other hand, 12 species were found only at one site and 9 species were found only at two sites (Table 1). The 5 species of Podostemaceae plus 11 species in other families (including a new species of *Pilea* Lindl.) were found only at sites outside the plots.

Thirty-three of the 41 species that were properly identified are widely distributed, ranging two or more countries, and, in some cases, spanning throughout most of the Neotropics (e.g., *Asplenium delicatulum* C. Presl, *Adiantum fructuosum* Poepp. ex Spreng, and *Cyperus simplex* Kunth), or even through other continents (e.g., *Lepidagathis alopecuroidea* [Vahl] R. Br. ex Griseb., *Asplenium formosum* Willd.). Elsewhere, these widespread species are sometimes found in other environments, and some of them are probably facultative rheophytes. In contrast, at least nine species are known only from

Table 1. Rheophytic Plants of the Samaná Norte River, Antioquia, Colombia.

Species	Voucher	Habit	Global distribution	IUCN category (reference)	Plots in which found	Frequency	Overall abundance	Substrate
Acanthaceae								
Hygrophila tyttha Leonard	*SH 3205*	H	Colombia, Ecuador	NE	10	1	3	Rock
Justicia namatophila Leonard	*SH 3208*	H	Colombia (Antioquia, Caldas)		6, 7, 8, 10	4	6.5	Sand, rock
Justicia polygonoides Kunth	*SH 3100*	SS	Colombia to Peru	NE	1, 2, 7, 8, 9, 10	6	14	Sand, rock
Justicia sp. 1	*SH 3101*	SS			9, 10	2	4	Sand, rock
Lepidagathis alopecuroidea (Vahl) *Griseb.*	*SH 3209*	H	Tropics in America and Africa	LC (Bernal et al., 2016)	1, 9	2	2	Sand, rock
Ruellia geminiflora Kunth	*SH 3103*	H	Mexico to Argentina	LC (Bernal et al., 2016)	7, 9	2	3	Rock
Apocynaceae								
Asclepias cf. woodsoniana Standl. & Steyerm.	*SH 3140*	S	Mexico to Colombia			1*	N/A	Sand, rock
Araceae								
Anthurium antioquiense Engl.	*SH 3107*	H	Colombia (Antioquia, Santander)	NE	1, 2, 3, 5, 6, 7, 9	7	15.5	Sand, rock
Spathiphyllum floribundum (Linden & André) N.E. Br.	*SH 3113*	H	El Salvador to Ecuador and French Guiana	NE	3, 4, 5, 6, 8, 9	6	10	Sand, rock
Araliaceae								
Dendropanax sp. nov.	*SH 3195, 3274, 3277*	S	Samaná River Basin	CR (this article)	6, 8	2	3	Rock
Arecaceae								
Aiphanes argos R. Bernal, Borchs. & Hoyos-Goméz	*SH 3125*	S	Samaná River Basin	CR (Gardiner & Bernal, 2017)	6, 7, 8	3	4	Rock
Ammandra decasperma O.F. Cook	*No voucher*	AP, S	Colombia and Ecuador	LC (Galeano et al., 2015)	1	1	1	Sand
Geonoma interrupta (Ruiz & Pav.) *Mart.*	*No voucher*	S	Mexico to Venezuela and N Bolivia	LC (Galeano et al., 2015)	8, 9	2	3.5	Sand, rock
Aspleniaceae								
Asplenium delicatulum C. Presl	*SH 3130*	H	Mexico to Argentina; Cuba	NE	3	1	1	Rock
Asplenium formosum Willd	*SH 3132*	H	Mexico and West Indies to Argentina; Africa, India	NE	7	1	2	Rock
Asteraceae								
Ayapana hylophila (B.L. Rob.) R.M. King & H. Rob.	*SH 3106*	S	Colombia (Antioquia, Bolívar, Córdoba, Santander, Tolima)	NE	5, 6, 7, 9, 10	5	15.5	Rock
Blechnaceae								
Blechnum asplenioides Sw.	*SH 3192*	H	South America; New Zealand	NE	5	1	2	Rock

(continued)

Table 1. Continued

Species	Voucher	Habit	Global distribution	IUCN category (reference)	Plots in which found	Frequency	Overall abundance	Substrate
Bromeliaceae								
Pitcairnia alversonii L.B. Sm. & Read	*SH 3156*	H	Colombia (Antioquia, Caldas)	VU (Betancur & García, 2006)				Wall
***Pitcairnia fluvialis** L.B. Sm. & Betancur*	*SH 3190*	H	Samaná River Basin	CR (this article)	7, 9	2	4	Rock
Vriesea chrysostachys E. Morren	*SH 3193*	H	Colombia to Bolivia; Caribbean					Wall
Cyclanthaceae								
Dicranopygium goudotii Harling	*SH 3102*	H	Colombia (Antioquia, Magdalena, Santander)	NE	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	10	30	Sand, rock
Cyperaceae								
Calyptrocarya glomerulata (Brongn.) Urb.	*SH 3123*	H	Mexico to Brazil and Bolivia		1, 3, 6	3	4	Sand
Cyperus simplex Kunth	*SH 3139*	H	Mexico to Brazil and Bolivia	NE	9	1	1	Rock
Fabaceae								
Calliandra purdiei Benth.	*SH 3114*	T	Colombia and Venezuela	NE	2, 4, 5, 6, 7, 8, 9	7	15	Sand, rock
Macrolobium colombianum (Britton & Killip) L. Uribe	*SH 3115*	T	Costa Rica to Ecuador	NE	2, 4, 7, 9	4	4	Sand, rock
Zygia longifolia (Willd.) Britton & Rose	*SH 3121*	T	Central America to Venezuela, Brazil and Peru	LC (Bernal et al., 2016)	2, 3, 4, 6, 7, 8, 9, 10	8	15.5	Sand, rock
Lauraceae								
Nectandra aff. microcarpa Meisn	*SH 3271*	S	Colombia to Peru and Brazil			1*	N/A	Rock
Lythraceae								
***Cuphea fluviatilis** S.A. Graham*	*SH 3109*	SS	Samaná River Basin	CR (this article)	5, 6, 8, 9	4	8.5	Rock
Cuphea sp.1	*SH 3179*	H			1	1	1	Sand
Melastomataceae								
Miconia sp. nov.	*SH 3105, 3194, 3270*	S	Samaná River Basin	CR (this article)	5, 7, 8, 9	4	8	Rock (sand)
Miconia mulleola Wurdack	*SH 3198*	S	N Colombia to E Venezuela		3	1	2	Sand
Miconia riparia Triana	*SH 3118*	SS	Colombia, Peru	NE	3, 5, 6, 7, 8, 9	6	12.5	Sand, rock
Monolena primuliflora Hook. f.	*SH 3138*	H	Central America to Peru and Brazil	NE	7	1	2.5	Rock
Triolena obliqua (Triana) Wurdack	*SH 3181*	H	Colombia to Peru	NE	3, 4	2	2	Sand
Myrtaceae								
Eugenia sp. 1	*SH 3141, 3189, 3191*	S			3, 4, 6, 9	4	9	Sand, rock
Myrcia sp. nov.	*SH 3117, 3196, 3276*	S	Samaná River Basin	CR (this article)	6, 9, 10	3	3	Rock

(continued)

Table 1. Continued

Species	Voucher	Habit	Global distribution	IUCN category (reference)	Plots in which found	Frequency	Overall abundance	Substrate
Oxalidaceae								
Biophytum boussingaultii R. Knuth	*SH 3119*	H	Colombia, Ecuador	NE	3, 5, 6, 8	4	6	Sand, rock
Piperaceae								
Piper sp. nov. 1	*SH 3197*	H	Samaná River Basin	CR (this article)		1*	N/A	Rock
Piper sp. nov. 2	*SH 3186*	S	Samaná River Basin	CR (this article)	2, 3, 4, 5, 6, 7, 8, 9, 10	9	23.5	Sand, rock
Poaceae								
Arundinella berteroniana (Schult.) Hitchc. & Chase	*SH 3184*	H	Mexico to Argentina			1*	N/A	Rock
Podostemaceae								
Marathrum morphosp. 1	*SH 3199*	H				1*	N/A	Rock
Marathrum morphosp. 2	*SH 3188*	H				1*	N/A	Rock
Marathrum morphosp. 3	*SH 3200*	H				1*	N/A	Rock
Marathrum morphosp. 4	*SH 3202*	H				1*	N/A	Rock
Marathrum morphosp. 5	*SH 3267*	H				1*	N/A	Rock
Primulaceae								
Ardisia cf. guianensis (Aubl.) Mez	*SH 3278*	S	Nicaragua to Brazil		1, 2, 3, 4	4	9	Rock
Ardisia morphosp. 1	*SH 3144*	S				1*	N/A	Sand
Pteridaceae								
Adiantum fructuosum Spreng.	*SH 3137*	H	Neotropics	NE	7	1	1	Rock
Adiantum nudum A.R. Sm.	*SH 3142*	H	Colombia, Venezuela, Brazil	NE	3, 5, 6, 7, 9	5	5	Sand, rock
Rubiaceae								
Psychotria psychotriifolia (Seem.) Standl.	*SH 3275*	S	Nicaragua to Ecuador and Venezuela		9, 10	2	8	Sand
Selaginellaceae								
Selaginella geniculata (C. Presl) Spring	*SH 3135*	H	Panama to Peru		2, 6	2	4	Rock
Selaginella flagellata Spring	*SH 3129*	H	Mexico and the West Indies to northern South America	NE		1*	N/A	Sand
Solanaceae								
Cestrum sp.	*SH 3177*	S		CR (this article)		1*	N/A	Rock
Tectariaceae								
Tectaria heracleifolia (Willd.) Underw.	*SH 3149*	H	S USA to Colombia and Venezuela			1*	N/A	Sand, rock

(continued)

Table 1. Continued

Species	Voucher	Habit	Global distribution	IUCN category (reference)	Plots in which found	Frequency	Overall abundance	Substrate
Thelypteridaceae								
Thelypteris angustifolia (Willd.) Proctor	*SH 3111*	H	Neotropics	NE	6	1	4	Rock
Thelypteris chocoensis A.R. Sm. & Lellinger	*SH 3112*	H	Colombia (Antioquia, Boyacá, Caldas, Chocó)	NE	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	10	41	Sand, rock
Urticaceae								
Pilea sp. nov.	*SH 3133*	H	Samaná River Basin	CR (this article)		1*	N/A	Rock

Note. Species known only from the Samaná basin are in bold face. For species found only outside the plots, the frequency (marked with*) refers to the number of sites where the species was seen. H = herb; S = shrub; SS = subshrub; T = tree; CR = critically endangered; LC = least concern; NE = not evaluated; VU = vulnerable; N/A = not applicable; SH = Saúl E. Hoyos-Gómez.

the Samaná Norte River basin and three more are known from just one or two localities outside the basin. All of these are obligate rheophytes and have not been found outside the river flood range (Table 1). Seven of the rheophytic species in the basin were discovered as new to science during this study.

Twenty-seven of the species (47% of all rheophytes found), including all the Podostemaceae, grew exclusively on rocks, whereas most of the remaining species grew either on rocks or on the sandy areas among them. Only eight species (14% of all rheophytes found) were found exclusively on sandy soil. Two of these were small, probably short-lived herbs (Table 1).

The highest concentration of species was found in the intermediate level of the rheophytic belt, where 38 species (66% of the total) were found. Only 11 species (19% of total number), including the 5 species of Podostemaceae, were restricted to the lower level of the belt, whereas only 2 species, the ferns *Adiantum fructuosum* and *Blechnum asplenioides* Sw., were restricted to the uppermost level. The predominant life form was herbs, with 35 species (60%), followed by shrubs and subshrubs (20 species, 34%), whereas trees were represented only by three species (5%; Table 1).

Discussion

The lack of studies on rheophytes in the Andes makes it impossible to put the number and composition of this group in the Samaná Norte River in context with other rheophytic floras in the region. The number of species, though, falls within the range found in three studies in southeastern Brazil (42 species, Klein, 1979; 47 species, Bernardes, 2012; 79 species, Köhler et al., 2016).

However, several lines of evidence point to an extremely specialized flora among the rheophytes of the Samaná Norte River basin. First, at least nine of the species (15% of all rheophytes) are endemic to the basin and seven of them remained undiscovered to science until this study, despite extensive exploration in the general area during the last 35 years.

Second, the occurrence of three rheophytic species of palms is surprisingly high, considering that only 18 species of palms have been recorded worldwide to belong to this biological group (Bernal et al., 2017), including the large acaulescent *Ammandra decasperma* O.F. Cook, recorded here for the first time as a rheophyte. So far, the Samaná Norte River has the world's largest known concentration of rheophytic palms.

Third, the number of species of Podostemaceae found in the basin (five) is the highest value recorded for any Neotropical river (Philbrick, Bove, & Stevens, 2010). As a matter of fact, the total number of Podostemaceae known to date in the Department of Antioquia was only three (Idárraga, Ortiz, Callejas Posada, & Merello, 2011), whereas the total number of species for the whole country was 17 (Bernal, Gradstein, & Celis, 2016).

Finally, one of the species of Bromeliaceae, *Pitcairnia fluvialis* L.B. Sm. & Betancur, is endemic to the Samaná Norte River basin, whereas another one, *Pitcairnia alversonii* L.B. Sm. & Read, is known from just two nearby localities besides this river. Although epiphytic species of bromeliads often have wide distributions, saxicolous and rheophytic species in the family are often geographically restricted, being usually endemic to small areas (Büneker, Pontes, Witeck-Neto, & Soares, 2015).

Implications for Conservation

Conservation Assessment

The nine species of rheophytes that are endemic to this basin (Table 1) occupy a narrow fringe along the steep slopes of the river canyon, normally no more than 15 m wide on each side or, for those species growing on the lower range of the rheophytic belt, no more than 10 m wide. Thus, their EAO is calculated as the width of this belt times the length they occupy along the river and its tributary creeks, up to the maximum elevation where they have been recorded. Table 2 shows the EAO calculated for each of them, based on their distribution along the river and the level they occupy on the rheophytic belt.

The Samaná Norte river area remained inaccessible to most people for over five decades, as a result of war. With the advent of peace in Colombia, the area has seen an increase of human activity on the less steep slopes of the canyon, as well as an increase in artisanal or mechanized mining along the river margins. Furthermore, the planned hydroelectric plant Porvenir II, which the Colombian Argos Group intends to build along the river, would flood a stretch of 16.5-km long upstream from the dam site. For most of the endemic species, this length represents a significant proportion of their known range (Table 2). Thus, although several of the species are still in the process of being described and named, we have deemed it appropriate to assess their conservation status, in order to call attention to the threats they face. To link the assessment to the species when they are officially named, we cite for each of them the corresponding vouchers. The nine species of Table 2 are here assessed as Critically Endangered, based on criteria B1ab(i,ii,iii,iv,v) and B2ab(i,ii,iii,iv,v), extent of occurrence estimated to be less than 100 km^2 [B1], EAO less than 10 km^2 [B2], known from a single location [a], and continuous decrease in extent of occurrence, EAO, area, extent or quality of habitat, number of locations or subpopulations, and number of mature individuals [b(i, ii, iii, iv, v)] (IUCN, 2012). Short information on each of these species is presented in the following.

Aiphanes argos. Recently described as a new species (Bernal et al., 2017), this small palm grows on rocks in the intermediate and high flood levels. Already included as critically endangered in IUCN's red list of threatened plants (Gardiner & Bernal, 2017).

Cuphea fluviatilis (Figure 4). Described as a new species in 2009, this small herb is abundant on rocks in exposed sites at low to intermediate flood levels. It was originally categorized as Data Deficient by Graham (2009), as it was known only from the type. Our study provides precise information on its distribution in the Samaná Norte River basin.

Dendropanax **sp. nov.** (vouchers: *Hoyos 3195, 3274, 3277*, HUA). A small shrub identified as a new species by specialist Álvaro Idárraga. It has been found at a few

Table 2. Estimated Area of Occupancy of Endemic of Plants Known Only in the Samaná Norte River Basin, Antioquia, Colombia, and the Percentage of That Area That Would be Flooded if the Hydroelectric Project Porvenir II Were Developed.

Species	Occupancy along the river (km)	Rheophytic belt width (m)	Estimated Area of occupancy EAO (km^2)	Percentage of the EAO that would be flooded by the Porvenir II dam
Pilea **sp. nov.**	1	15	0.03	100
Peperomia **sp. nov.**[a]	1	N/A	1	100
Aiphanes argos	30	15	0.9	80
Dendropanax **sp. nov.**	14.4	10	0.28	68
Myrcia **sp. nov.**	30.3	10	0.61	68
Cuphea fluviatilis	32.7	10	0.65	40
Miconia **sp. nov.**	32.7	10	0.65	40
Pitcairnia fluvialis	32.7	15	0.98	40
Piper **sp. nov.**	64.2	10	1.28	28

Note. EAO: Estimated Area of Occupancy.
[a]Nonrheophytic plant.

Figure 4. *Cuphea fluviatilis*, a critically endangered species known only from the Samaná River basin, in Antioquia, Colombia, where it is abundant on exposed rocks. Forty percent of its population would disappear if the Porvenir II dam were built.

places along a tract less than 15 km along the river, growing on rocks at intermediate flood level.

Miconia **sp. nov.** (vouchers: *Hoyos 3105, 3194, 3270*, HUA). A shrub being described as a new species by specialists Frank Almeda and Mauricio Posada. It grows mostly on rocks or occasionally on sand at low or intermediate flood level.

Myrcia **sp. nov.** (Figure 5; vouchers: *Hoyos 3117, 3196, 3276*, HUA). A shrub being described as a new species by specialist Carlos Parra. It grows on rocks at low to intermediate flood levels.

Peperomia **sp. nov.** (voucher: *Hoyos 3145*, HUA). A nonrheophytic herb known from a single site near the river margin in a karst formation. Being described and named by specialist Ricardo Callejas.

Pilea **sp. nov.** (voucher: *Hoyos 3133*, HUA). This small herb, identified as a new species by specialist Ana Isabel Vásquez was found only on the rocky walls of a small creek that cascades into the Samaná. It was not found at any of the plots nor did we see it anywhere else along the river.

Piper **sp. nov.** (voucher: *Hoyos 3186*, HUA). This is a common shrub being described and named as a new species by specialist Ricardo Callejas. It grows on rocks or sand at low and intermediate flood levels.

Pitcairnia fluvialis. Described from the Samaná Norte River in 1991, this bromeliad grows on exposed rocks or rocky walls along the river. Categorized as endangered by Betancur and García (2006), based on just two specimens from close sites. Information from this study now allows it to be recategorized as Critically Endangered.

Impact of Planned Damming

The proposed dam for the hydroelectric plant Porvenir II would flood a tract of 16.1 km of the Samaná Norte River, transforming lotic environments into lentic ones. It would affect the range of at least nine species of endemic plants, reducing their known range 28% to 100% (Table 2). For at least two species of plants, *Pilea* sp. nov. and *Peperomia* sp. nov., the reservoir would drown all known populations, thus virtually leading them to extinction. For the remaining species (Table 2), which are here assessed as critically endangered, a reduction of 40% to 80% in their range would worsen their situation significantly.

Figure 5. *Myrcia* sp., a critically endangered new species known only from the Samaná River basin, Antioquia, Colombia, where it has an estimated area of occupancy (EAO) of just 0.61 km^2. Sixty-eight percent of its population would disappear if the Porvenir II dam were built.

For species found downstream from the dam, the threat is not flooding but a change in the hydrological dynamics of the river, which would deprive the plants from the cycles of flood and drought that have determined their evolution and which probably play a vital role in their reproduction. The Podostemaceae, for example, are known to depend on the periodic occurrence of high and low water levels, developing vegetative structures during periods of flood, and reproducing during the dry season, when the rocks are exposed (Khanduri, Chaudhary, Uniyal, & Tandon, 2014; Mohan Ram & Segal, 2007). Unlike many other aquatic plants, Podostemaceae are not known to propagate by any vegetative means (Philbrick, 1997)

Relocation of individuals of narrowly endemic species is a difficult alternative, which often proves unsuccessful (see, e.g., Zimmermann, 2011). This may be particularly true for those species growing on rock crevices, like *Cuphea fluviatilis*, *Miconia* sp. nov., *Dendropanax* sp. nov., or the species of Podostemaceae, which are firmly attached to submerged rocks. The former are usually deeply rooted in the crevices and are hard to extract without damage; the latter are so strongly attached, that even obtaining a good plant for a botanical specimen proves almost impossible.

Considering that none of the nine endemic species here categorized as Critically Endangered was included in the Environmental Impact Study whereupon the construction license was granted by ANLA (Integral, 2012) and that 55 out of the 59 species of rheophytes discussed here were not included in that study either, we recommend that the license be reconsidered. When Earth is facing its sixth mass extinction event, this time caused by human activities (Barnosky et al., 2011; Ceballos, Ehrlich, & Dirzo, 2017), it is not advisable to start works that a priori are known to threaten critically endangered species or even to lead some of them to extinction.

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ORCID iD

Rodrigo Bernal http://orcid.org/0000-0002-9832-8498.

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