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A new species and a new record for *Cedrela* (Meliaceae, Sapindales) in Ecuador: morphological, molecular, and distribution evidence

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Abstract

A new *Cedrela* (Meliaceae) species, *Cedrela angusticarpa*, is described through a combination of taxonomic, morphological, and molecular analyses. *Cedrela kuelapensis*, originally described as an endemic species of northern Peru, is also reported here as a new record for Ecuador. *Cedrela angusticarpa* has oblong or oblong-lanceolate glabrous leaflets, rounded at the base. Inflorescences are up to 70 cm long, and flowers present a cupuliform calyx with five regular teeth. Fruits are narrowly obovoid capsules. Through molecular analyses using nine microsatellite loci, it is evident that samples from *C. angusticarpa* form their own genetic cluster when compared to the most morphologically similar species, *C. odorata*, suggesting that they belong to a new separate species. Additionally, here we report that *C. angusticarpa* has a very narrow geographic range, recorded between 550 and 1300 m in elevation, and restricted to the relatively small areas of northwestern Ecuador. Climatic niche modelling techniques were used as a proxy for assessing potential distributions and habitat loss percentages for both *C. angusticarpa* and *C. kuelapensis*. Finally, IUCN Red List categories and criteria were applied to assess the conservation status of both *Cedrela* species analyzed here.

Key words: Andes Mountain Range, *Cedrela angusticarpa*, *Cedrela kuelapensis*, “cedro”, endemic species

Introduction

Cedrela P.Browne (1756: 158) is a genus of large trees, with lenticellate twigs, pinnate leaves, and leaflets almost always presenting an asymmetrical base and domatia. Flowers are usually 5-merous, showing a lobed calyx—sometimes with

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the side split to the base—and presenting five regular or irregular lobes or teeth, and petals and stamens partially adnate to the walls of a gynophore. Fruits are woody capsules with five lenticellate dehiscent valves, and winged seeds attached to the apex of an angled or winged columella (Pennington & Muellner 2010, Köcke *et al.* 2015).The genus has 19 species described so far (see Pennington & Muellner 2010, Köcke *et al.* 2015, Palacios *et al.* 2019), that vary in their distribution and habitats. For example, *C. odorata* Linnaeus (1759: 245) is recorded from northern Argentina to Mexico (www.tropicos.org), mostly in wet ecosystems. In contrast, other species like *C. fissilis* Velloso (1825: 75) for example, present more restricted latitudinal ranges when compared to *C. odorata*, but they are usually present in both dry and wet environments. However, most of the *Cedrela* species present restricted distributions and are known from only a few localities (Muellner *et al*. 2010). For Ecuador, six species have been reported up to date (see Palacios 2007, Pennington & Muellner 2010, Palacios *et al.* 2019). However, this relatively high diversity is apparently underestimated in this country (Cavers *et al*. 2013), as different morphotypes are still being recognized in the field and in local herbariums (W. Palacios, G. Rivas-Torres pers. obsv.). In fact, it is still necessary to unveil the real diversity of *Cedrela* in Ecuador, not only to have a better idea of the different species that are naturally grouped in this genus, but also to generate the first-hand information necessary to delineate urgent sustainable management and conservation plans for this important taxonomic group.

Cedrela is a particularly relevant genus in tropical America because of the great value of its wood, considered one of the finest in the world for cabinetmaking, handicrafts, and valuable timber items (International Tropical Timber Organization, www.tropicaltimber.info). "Cedro", as many of the species within this genus are commonly known, has been widely used for centuries. For instance, it is very well documented that several of the churches in Quito's world-famous downtown have used cedro wood beams and furniture as part of their structure and architectural appeal. In San Agustin Church's "Sala Capitular", built between 1741 and 1761 (and where Ecuador's Act of Independence of was signed in 1809), benches, chairs, and tables are carved from cedro wood. There are references from 1573 (act of the Cabildo de Quito) and 1802 (by Alejandro von Humboldt) that indicate that the wood of "cedrela" and "cedro" was used to build houses and temples in the old city of Quito (Hidalgo 1998).

In recent years, the number of publications and the molecular tools available to define *Cedrela* species' relationships have increased (Hernández *et al.* 2008, Finch *et al.* 2019). However, is still necessary to work on the identification and description of new species to clarify the evolutionary relationship issues that exist for this genus (Cavers *et al.* 2013). The use of taxonomy, in combination with molecular markers, can assist in the task of deciphering the actual number of species registered for a genus such as *Cedrela* in a megadiverse country like Ecuador.

Additionally, the use of spatially explicit models that feed on information from local records and site-level occurrences can be used as a proxy to preliminarily define the potential distribution areas for *Cedrela* species (Kumar & Stohlgren 2009). This type of information is urgently needed to perform, among others, updates to IUCN red lists (Fivaz & Gonseth 2014). At the moment, only 8 out of 19 species of *Cedrela* are evaluated according to IUCN categories and criteria (for details please see https://www.iucnredlist.org/search?query=Cedrela&searchType=species). Likewise, the lack of information regarding the real number of *Cedrela* species does not allow the efficient use of IUCN-type tools, and thus prevents the improvement of conservation and forest management policies and plans.

Therefore, the objective of this study is to provide relevant taxonomic, molecular, and biogeographical information related to two species of *Cedrela* in Ecuador. Specifically, here we present taxonomic, morphological, and molecular evidence to describe *C. angusticarpa* as a new species for the genus; we also provide evidence for a new record of *C. kuelapensis* T.D.Penn. & A.Daza in Pennington & Muellner (2010: 65) in Ecuador; and finally, we utilize widely used spatially explicit models as proxies for assessing the potential distribution of both species in Ecuador. Also, and using real occurrences recorded for Ecuador (and verified for each species by the specialist), we present a general analysis regarding the threats, and thus conservation status—using IUCN categories and criteria—for these two species.

Materials and methods

Morphological and taxonomic comparisons: Individuals of *C. angusticarpa* and *C. kuelapensis* located in the field were measured and associated with a geographic coordinate, and a fertile branch of each tree was collected, processed, and dried to later elaborate vouchers for herbarium comparisons regarding main morphological traits (Table 1). For this study, all the herbarium specimens classified as *Cedrela* deposited in LOJA, MO, QCA, and QCNE (acronyms follow Thiers 2018) were examined and contrasted with those vouchers collected in the field.

TABLE 1. Unique collection number (ID collection) and herbaria where the samples of *Cedrela* used in this study were deposited. Individuals used for potential distribution models (+) and used for molecular analyses (*) are also identified.

Species	ID collection	Herbarium
Cedrela angusticarpa[*+]	Palacios *et al.* 18406	QCNE, QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18407	QCNE, QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18408	QCNE, QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18411	QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18412	QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18413	QCNE, QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18414	QCNE, QUSF
Cedrela angusticarpa[*+]	Palacios *et al.* 18445	QCNE
Cedrela angusticarpa[*]	Palacios *et al.* 18435	QCNE
Cedrela angusticarpa	Pérez *et al.* 3255	QCA
Cedrela angusticarpa	Palacios *et al.* 18466	QCNE
Cedrela kuelapensis	Sánchez & Gonzaga 124	LOJA
Cedrela kuelapensis[+]	*Merino et al. 4617*	LOJA
Cedrela kuelapensis[+]	Borgtoft *et al.* 104298	LOJA, QCA
Cedrela kuelapensis[+]	Palacios *et al.* 18284	QCNE
Cedrela kuelapensis[+]	Palacios *et al.* 18292	QCNE
Cedrela kuelapensis[+]	Palacios *et al.* 18288	QCNE
Cedrela odorata[*]	Palacios *et al.* 18332	QCNE
Cedrela odorata[*]	Palacios *et al.* 18333	QCNE
Cedrela odorata[*]	Palacios *et al.* 18345	QUSF
Cedrela odorata[*]	Palacios *et al.* 18347	QUSF
Cedrela odorata[*]	Palacios *et al.* 18348	QUSF
Cedrela odorata[*]	Palacios *et al.* 18349	QUSF
Cedrela odorata[*]	Palacios *et al.* 18356	QUSF
Cedrela odorata[*]	Palacios *et al.* 18359	QUSF
Cedrela odorata[*]	Palacios *et al.* 18365	QUSF
Cedrela odorata[*]	Palacios *et al.* 18377	QUSF
Cedrela odorata[*]	Palacios *et al.* 18422	QUSF
Cedrela odorata[*]	Palacios *et al.* 18423	QUSF
Cedrela odorata[*]	Palacios *et al.* 18424	QUSF
Cedrela odorata[*]	Palacios *et al.* 18425	QUSF
Cedrela odorata[*]	Palacios *et al.* 18426	QUSF
Cedrela odorata[*]	Palacios *et al.* 18428	QUSF
Cedrela odorata[*]	Palacios *et al.* 18429	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT1	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT2	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT3	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT4	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT5	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT6	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT7	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* COT8	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC2	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC3	QUSF

......*continued on the next page*

TABLE 1. (Continued)

Species	ID collection	Herbarium
Cedrela odorata[*]	Rivas Torres *et al.* CC4	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC5	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC6	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC7	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC8	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC9	QUSF
Cedrela odorata[*]	Rivas-Torres *et al.* CC10	QUSF

For species distribution and comparisons with types not deposited at the above cited herbaria, we consulted the Tropicos® database (http://www.tropicos.org, 2018) and Global Plants on Jstor (http://plants.jstor.org 2018). Measurements presented here for description were taken from dried specimens.

For those individuals hypothesized to be *C. kuelapensis*, collected samples were confirmed with herbarium material and species descriptions (Pennington & Muellner 2020), while for *C. angusticarpa*, taxonomic, morphological, and molecular analyses were performed to support its recognition as a new species.

Samples and data for molecular analyses: DNA was extracted from silica-gel dried leaf tissue from individuals located in the field and associated with a corresponding voucher (Table 1), following the protocol described by Rezadoost *et al*. 2016 (Appendix 1). Nine microsatellite loci designed for *C. odorata* (Hernández *et al.*, 2008) were used for PCR amplification (Appendix 2; Table S1) and PCR products were sent to Macrogen South Korea for genotyping. Fluorescence peaks were analyzed in GeneMarker Software (Softgenetics, State College, PA, USA) to produce an allelic matrix for all sampled individuals (Table S2). To analyze how genetically distinct the *C. angusticarpa* samples are when compared to other closely related *Cedrela* species, a Principal Coordinate Analysis was performed (Appendix 3).

For the molecular analyses, *C. odorata* individuals were used as a control group to test if *C. angusticarpa* is in fact a different species, since the former is the most morphologically similar species to the newly described one.

Data collection for potential distribution analysis: Using the eight records for *C. angusticarpa* and five records for *C. kuelapensis* collected for this study (Table 1), species distribution models (fed with BIOCLIM bioclimatic variables with a resolution of 30s/c.1 km; Bioclim, Hijmans *et al.* 2005) were performed under the MaxEnt program v.3.4.0 (Phillips *et al.* 2017). For more details on the modelling techniques please refer to Appendix 4. The map resulting from this stage was corrected by masking out non-suitable ecosystems for species occurrence (identified by taxonomic specialist W. Palacios). Finally, for this stage, deforested surface and vegetation coverage (using updated in-country data, Mapa Histórico de Deforestación 2014-2016 (MAE 2017), and Mapa de Uso y Cobertura 2018, (MAE 2019) were projected with the resulting binary map modelling potential species distributions, in order to mask out and obtain the habitat loss percentage and population size reductions for each analyzed taxon, which subsequently allowed us to analyze IUCN criterion A (following Feria-Arroyo *et al*. 2009).

Data collection and analyses of conservation status: Specifically, here we used criteria A (specifically A2: population size reduction) and B (geographic range) included within the IUCN framework, to assess conservation status of both target species.

We used criterion A in addition to criterion B, which is usually applied in studies like the present one, to include habitat loss as a direct factor threatening the conservation of the analyzed species. We then used criterion A (as also used by other similar studies, see Feria-Arroyo *et al*. 2009) as a proxy for population size reduction, since the areas where the studied *Cedrela* species were recorded suffer from extensive habitat transformation, and thousands of hectares—along with thousands of adult trees—are lost every year (Tapia-Armijos *et al.* 2015; Rivas *et al.* 2021).

The data for the application of criterion A come from the results of the modeling techniques described in the previous section, where the percentage of habitat lost—calculated to establish the natural area that is conserved—allowed us to determine the reduction in population size and evaluate each species according to criterion A (Feria-Arroyo *et al*. 2009). The data for the application of criterion B, which includes the calculation of AOO and EOO, were obtained by analyzing the points of occurrence of each species using the open access tool Geospatial Conservation Assessment (Bachman *et al.* 2011) GeoCAT; available at http://geocat.kew.org/) and validated by the IUCN.

This latter tool produces, as outcomes, the Extent of Occurrence (EOO) and the Area of Occupancy (AOO) (IUCN 2019) for each species, using presence records. These records are part of the collections used here to describe the target species (Table 1).

Results

Taxonomic treatment

Cedrela angusticarpa W. Palacios, *sp. nov*. (Figures 1 & 2).

Type:—ECUADOR. Esmeraldas: Quinindé, Rosa Zárate, Reserva FCAT, El Descanso, 513 m, 0°22'N, 79°40'W, 23 January 2022, fl., few old fruits attached to the branches, *W. Palacios*, *F. Castillo & J. Olivo 18755* (holotype: QCNE 260031 - leaves and inflorescence; QCNE 260032 - leaves and fruits, isotype: MO).

Diagnosis:—*Cedrela angusticarpa* is related to *C. odorata*. The distinctive characteristics of these species are: a) leaflets oblong to oblong-lanceolate, base obtuse or rounded, (8–)9–15 × (4–)5–6 (–7) cm in *C. angusticarpa* vs leaflets oblong, oblong-falcate, base usually strongly asymmetric and rounded on one side, acute or obtuse on the other, 7–14 × 2.5–4 cm in *C. odorata*; b) inflorescence a robust-erect panicle, 40–70 cm long in *C .angusticarpa* vs a curved panicle, 15–40 cm long in *C. odorata*; c) calyx with five teeth in *C. angusticarpa* vs calyx 2–3-lobed in *C. odorata*; d) fruits narrowly obovoid, 1.3–1.8 cm in diameter, base acute, sometimes slightly 5-angled when dry in *C. angusticarpa* vs fruits oblong or ellipsoid, 1.8–2.6 cm in diameter, base rounded or obtuse in *C. odorata*.

Trees up to 30 m high; young branches 0.8–1.1 cm in diameter, glabrous, with circular or elliptic, scattered lenticels; young buds puberulent, covered by ovate scales 0.4–0.6 mm long. Leaves paripinnate, 45–70 (75) cm long; petiole 9–15 cm long, terete, glabrous, lenticellate; rachis 30–70(–80) cm long, terete, glabrous, lenticellate. Leaflets (6–)8–10(–13) pairs, (8–)9–15 × (4–)5–6 (–7) cm, opposite or sub-opposite, oblong, oblong-lanceolate, rarely slightly falcate, coriaceous, glabrous or with very short and scattered trichomes, shinning above; apex acuminate; base rounded, symmetric or, less frequently, with a slightly uneven side; venation eucamptodromous; secondary veins 9–14 pairs, parallel to each other and curved towards the margin; intersecondary veins absent or inconspicuous, or only present between few pairs of secondary veins; tertiary veins inconspicuous or not visible to the naked eye; petiolules 3–5 mm long, terete. Inflorescence is a broadly pyramidal panicle, 40–70 cm long, curved; lateral branches up to ca. 35 cm long; peduncle and rachis lenticellate, glabrous. Flowers 8–9 mm long; pedicel 0.8–1 mm long; calyx cyathiform, 2–2.3 mm long, puberulent, 5-dentate, teeth ovate with acute apex, symmetric, 0.8–1.1 mm long, with obtuse or rounded apex; petals 5, oblong, oblong-spatulate or oblong-lanceolate, 7–7.5 × 1.8–2.1 mm, adnate to androgynophore in the lower half, moderately puberulent inside, densely puberulent outside; stamens (free portion) 1.9–2.1 mm long, glabrous; ovary broadly ovoid, glabrous, style with thick discoid head. Capsule narrowly obovoid and tapering towards the base, apex rounded, base acute, sometimes slightly 5-angulated in dry condition, 3.5–5.5 × 1.4–1.8 cm in diameter, with scattered lenticels; valves 0.7–1.1 cm wide. Seeds 3–3.5 cm long.

Flowering and fruiting period:—Flowering occurs in the dry season, between July and September. The fruits are mature about seven months after flowering.

Distribution and habitat:—*Cedrela angusticarpa* is restricted to the foothill forests of the western Andes Mountain Range of northern Ecuador, between 550 and 1300m in elevation mainly between the cantons of San Miguel de los Bancos and Santo Domingo, along the Las Mercedes road and in the mountains of Mache (canton Quinindé) between 400 and 700 m.

As a result of the climatic modeling, it was observed that *C. angusticarpa* shows a relatively small potential distribution area in the provinces of Pichincha, Santo Domingo de los Tsachilas, and Esmeraldas. Within this distribution, some individuals of this species can also be recorded in grasslands as part of the tree vegetation that farmers leave as shade or to keep individuals for high-quality wood provision (Figure 3).

Etymology:—The specific epithet refers to the narrow fruits recorded in this taxon, although the length is equivalent to that of other species.

Conservation status of *Cedrela angusticarpa*:—Endemic to Ecuador. The modeled geographic distribution showed that the species' habitat has been lost by ~80% due to the expansion of agricultural and livestock frontiers. As mentioned before, where found, most of *C. angusticarpa* individuals are growing in secondary forests. Calculated Extent of Occurrence (EOO) resulted in 1,607.06 km², and the area of occupancy (AOO) was calculated to be 36 km² for this species. Due to the habitat loss and its restricted distribution, and using IUCN Categories and Criteria (2019), the species should be considered as Critically Endangered (CR A2cd). This conclusion is validated by W. Palacios, Meliaceae specialist for Ecuador.

FIGURE 1. *Cedrela angusticarpa*: Branch with inflorescences. *W. Palacios et al. 18445*. Photograph by W. Palacios.

Field characteristics:—*Cedrela angusticarpa* is a tree that reaches up to 30 m in height and ca. 1.6 m in dbh. Adult trees have rough or superficially cracked bark (Fig. 2A). In open places, the crown is wide, rounded, and dense (i.e. many leaflets and leaves), with a dark green color.

Common names and local uses:—Local name: "cedro". Farmers of the Santo Domingo and San Miguel de los Bancos use this species as wood provision (for building houses) and as cattle shading. On the other hand, in the mountains of Mache, where it seems that the populations were more abundant, between 1995 and 2005, the peasants sold the adult trees to merchants who, in turn, sold the wood in the national market.

Taxonomic relationships:—Vegetatively, *C. angusticarpa* is close to *C. odorata* L. The taxonomic differences between these species are detailed in the diagnosis. At this point, one must remember that Pennington & Muellner (2010) indicate that *C. odorata* may be treated as a compound of species that include three taxonomic entities, one of which occurs in Ecuador and Guyanas. This observation was corroborated by Cavers *et al*. (2013), who used several molecular markers for phylogenetic analyses of *Cedrela*, with an emphasis on *C. odorata*. Using internal transcribed spacer (ITS) sequence data obtained from a large sample of *C. odorata* from Central and South America and the Caribbean, and following the work done by Pennington & Muellner (2010), Cavers *et al.* (2013) identified 22 haplotypes, four of them corresponding to specimens from the coast of Ecuador, which formed a clade with *C. montana* Moritz ex Turczaninow (1858: 415) and *C. angustifolia* DC. (1824: 624), both of which are montane species. Despite having a close genetic affinity with these two montane species, most of the specimens analyzed by Cavers *et al.* (2013) were obtained from trees showing a clear *C. odorata* morphology. One of the specimens (*Perez et al. 3255*, QCA 133167) cited by Cavers *et al.* (2013) as belonging to *C. odorata* was analyzed here and placed under *C. angusticarpa*.

FIGURE 2. *Cedrela angusticarpa*: A. bark of an adult tree, B. lower surface leaflets (scale bar = 6 cm), C. lower surface leaflets (scale bar = 2.5 cm), D. flower (scale bar = 0.4 cm), E. cymule of inflorescence (scale bar = 1 cm), F. old fruit. A. *W. Palacios et al. 18407*; B, C, *W. Palacios et al. 18413*; D, E, *W. Palacios 18445;* F, *W. Palacios 18755*. All photographs by *W. Palacios.*

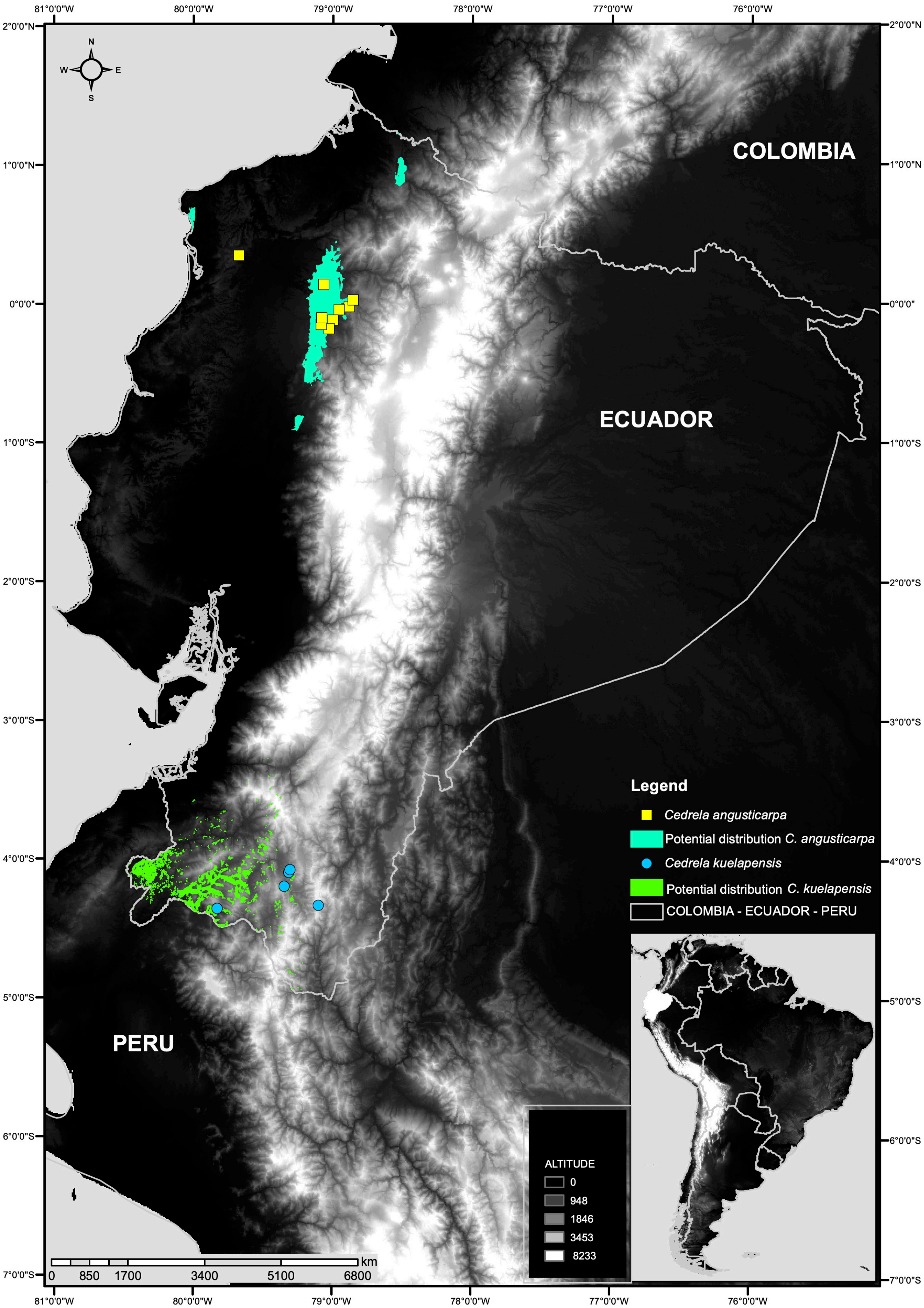

FIGURE 3. Map detailing the potential distribution and locations of individuals used for climatic niche modeling of *C. angusticarpa* and *C. kuelapensis* in continental Ecuador. Peru is located to the south and Colombia to the north of Continental Ecuador defined in this map.

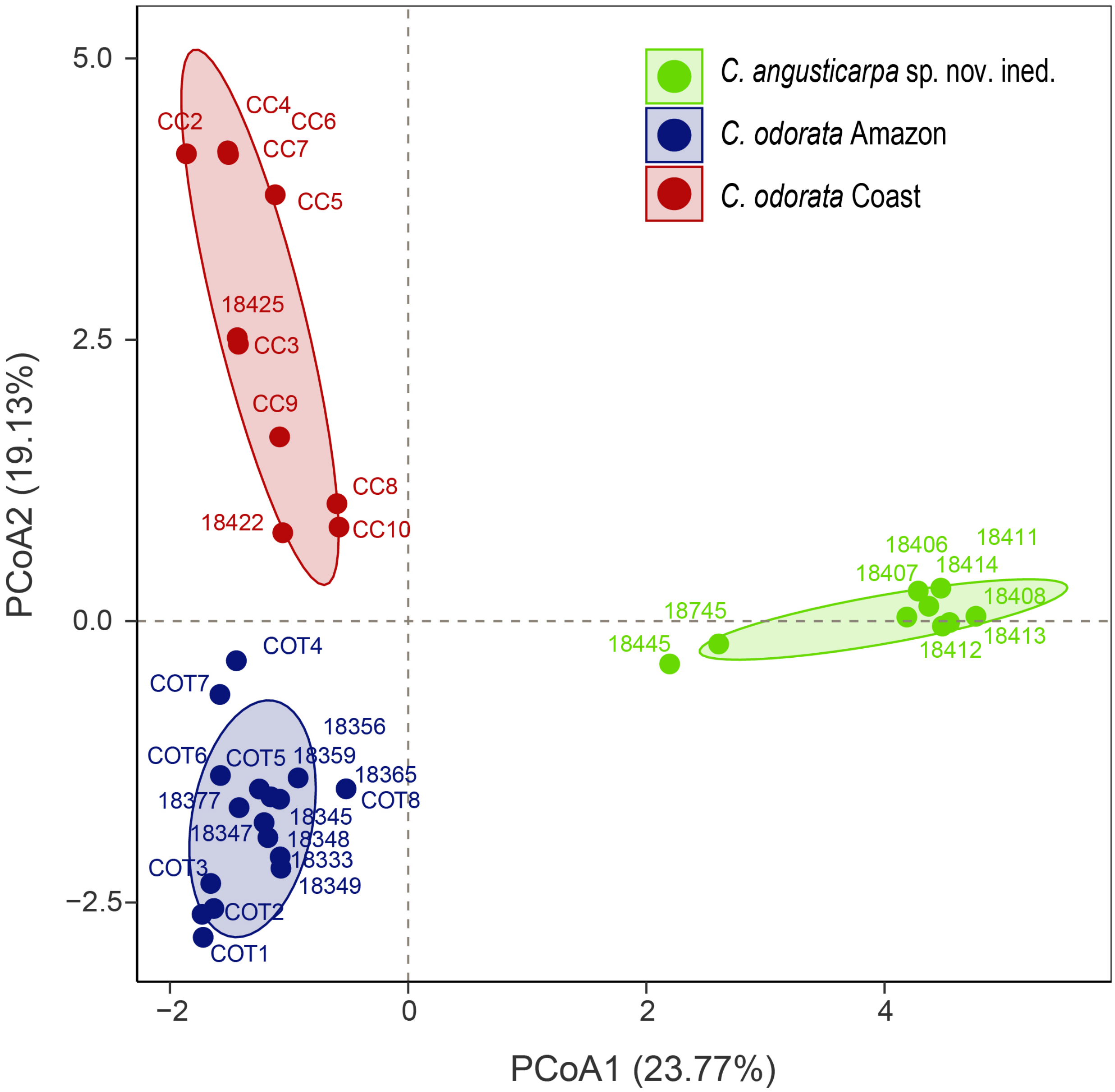

FIGURE 4. Principal Coordinate Analysis (PCoA) for sampled individuals of *C. angusticarpa* and *C. odorata* for the first two principal coordinates, which explain 42.9% of the variation in the data. Samples from *C. angusticarpa* (green) clearly segregate from samples of *C. odorata* from the Coast (red) and Amazon (blue) regions.

Specimens examined:—ECUADOR. Esmeraldas: Quinindé, Santa Isabel, Refugio del Gavilán, REMACH, 541 m, 648298W, 41878N, 27 August 2020, *Palacios et al. 18745* (QCNE); January 2023, *Palacios et al. 18831, 18832* (QCNE). Pichincha: San Miguel de Los Bancos, vía principal a Quito, cerca del sector Solaya, aprox. 5 km antes de Los Bancos, 1100 m, 1180, 0°01'33"N, 78°51'34"O, 5 Jun 2019, *Palacios 18435, 18445* (QCNE). Los Bancos-Las Mercedes, 605 m, 0°10'03"S, 79°05'13"W, 18 March 2007, *Pérez et al. 3255* (QCA). Vía a Santo Domingo, sector 23 de June, potreros, 1191, 0°1'16"S, 78°53'09"W, 7 April 2019, *Palacios et al. 18406* (QCNE). San Miguel de Los Bancos, sector Nuevo Amanecer, 857 m, 0°2'36"S, 78°57'37"W, 4 April 2019, *Palacios et al. 18407* (QCNE). Vía a Santo Domingo, entre Mulaute y Las Mercedes, 698 m, 0°07'09"S, 79°0'15"W, 13 June 2018, *Palacios et al. 18408* (QCNE). **Santo Domingo de los Tsáchilas:** vía a Santo Domingo, sector Las Mercedes, 751 m, 0°10'44"S, 79°01'50"W, 6 June 2018, *Palacios et al. 18466* (QCNE); sector río Achotillo, potreros, 581 m, 0°08'58"S, 79°05'09"W, 7 June 2018, *Palacios et al. 18412*, *18413*, *18414* (QCNE).

Molecular evidence supporting the differentiation of *C. angusticarpa* from *C. odorata*:—The PCoA, based on nine microsatellite loci, produced a two-dimensional plot for the first two principal coordinates (Figure 4), which accounted for 42.9% of the data variation. The samples of *C. angusticarpa* clearly formed their own genetic cluster when compared to *C. odorata* populations located in the Coast and Amazon regions in Ecuador, suggesting that they belong to a new, separate species.

Cedrela kuelapensis T.D. Penn. & Daza (2010: 65–68).

Cedrela has been considered endemic to northern Peru (Pennington & Muellner (2010), however, today it is known to be widely distributed, also, in the Loja province of Ecuador (Figure 5).

Field characteristics:—Tree up to 18 m high and 65 cm dbh, slightly fissured grayish bark, rounded crown. The flowers have pink petals with margin cream.

Flowering and phenology:—The species shows asynchronous phenology, as happens with other species of the genus in Ecuador. In December of 2017, for example, in the northeast of Loja, some trees had leaves and others were defoliated, while towards the central part of the province, a few trees had flowers and others were presenting young leaves. In August 2018 on the other hand, when a strong dry season was present in the central and southern part of the province (e.g., in Nambacola and Cariamanga sites), the trees were defoliated and some had old fruits; meanwhile, towards the northeast of Loja, the trees presented leaves and very young inflorescences.

Distribution and habitat:—Until now, the species was considered endemic to Peru (Pennington & Muellner 2010). In Ecuador, *C. kuelapensis* inhabits only the seasonally semi-deciduous forests of southern Ecuador, in the province of Loja, northern Peruvian border. The first collections of this species in Ecuador were made in 1995, in forest remnants occurring ~1600m in elevation, between Malacatos and El Tambo localities. Recent collections during this investigation (Table 1) expand the distribution of the species, which is now reported between 700 and 1600m in elevation. All the collected individuals were found in degraded areas along roads, pastures, and forest remnants.

In Loja, this species occurs in ecosystems like those where it grows in Peru; it grows associated with *Jacaranda sparrei* A.H. Gentry (1977: 138) and *Vachellia macracantha* (Humboldt & Bonpland ex Willdenow 1806: 1080) Seigler & Ebinger (2005: 160), but it has also been located at about 700m in elevation, usually growing on the banks of watercourses, in dry forests dominated by *Cochlospermum vitifolium* (Willdenow 1809: 720) Sprengel (1895: 596).

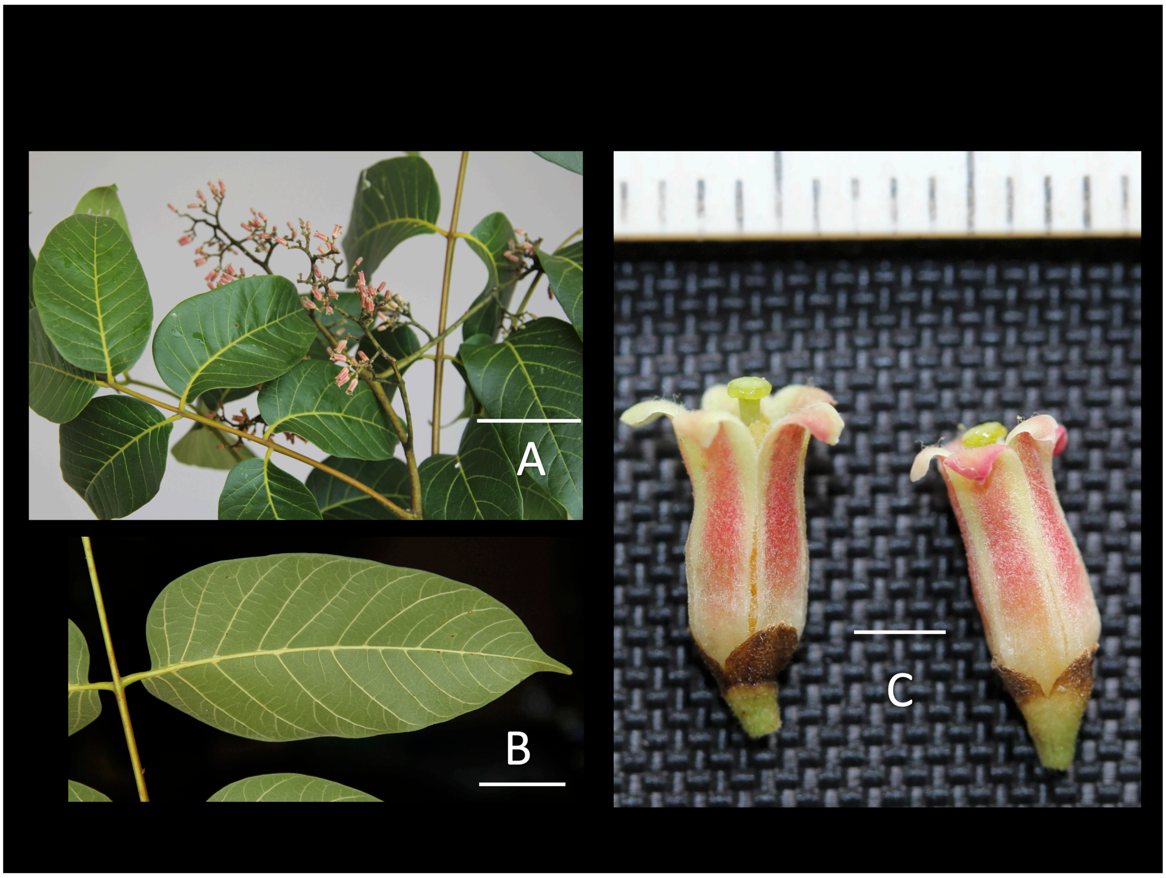

FIGURE 5. *Cedrela kuelapensis*: A. leaves (scale bar = 8 cm), B. leaflets (scale bar = 3 cm), C. flower (scale bar = 0.3 cm). A-C *Palacios 18292*. Photographs by *W. Palacios*

Conservation status:—*Cedrela kuelapensis* has a potential distribution area that covers a large part of the province of Loja (Figure 3), which significantly increases the previously known distribution area in Peru. However, it must be considered that the forests of this Ecuadorian province are mainly at secondary succession stages. Also (and according to resulting maps, Figure 3), the species faces a habitat loss of 54%, calculated after applying criterion A, an Extent of Occurrence (EOO) of 1,167.182 km², and an Area of Occupancy (AOO) of 20 km². These data, which were analyzed under the IUCN Red List Categories and Criteria (IUCN, 2019), suggest that the species could be evaluated as Endangered. However, considering that the potential reduction in its population size is at least 61% and a maximum of approximately 80% (W. Palacios pers. obs.), and that the trees mainly occur in secondary forests and are sparse and distant from each other, the species should be evaluated as Critically Endangered (CR A2c) for the country.

Specimens examined:—ECUADOR. Loja: Cantón Olmedo, vía a Surapo, 1660 m, October–November 2018, *Sanchez & Gonzaga 124* (LOJA). Malacatos-El Tambo road, near the village El Era, 1600 m, 16 May 1995, *Borgtoft et al. 104298* (LOJA, QCA). Km 12 Malacatos-Gonzanamá, 1280 m, 4°12'S, 78°21'W, 21 November 1995, *Merino et al. 4617* (LOJA). Catamayo, vía intervalles Malacatos-Catamayo, 2 km antes de El Tambo, 1533 m, 4°04'S, 79°18'W, 24 December 2017, *Palacios 18284*, *18285* (QCNE). Cariamanga, Vía Cariamanga-Colaisaca, aprox. 7 km, sector San Pedro, 1835 m, 4°20'06''S, 79°06'W, 24 December 2017, *Palacios 18292* (QCNE). Macará, Sabiango, lecho de quebrada, hacia el NW de Sabiango, Bosque seco, 760 m, 4°21'S, 79°49'W, 27 December 2017, *Palacios 18288* (QCNE). NC: cedro blanco.

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This work is dedicated to the memory of our friend and longtime QUSF curator Vlastimil Zack.

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