CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Nineteenth meeting of the Conference of the Parties
Panama, 14-25 November 2022

CONSIDERATION OF PROPOSALS FOR AMENDMENT OF APPENDICES I AND II

A. Proposal

To include the species *Dipteryx alata*, *Dipteryx micrantha, Dipteryx odorata* and *Dipteryx oleifera* in Appendix II of CITES in accordance with Article II, paragraph (2)(a) of the Convention and satisfying Criterion B of Annex 2a of Resolution Conf. 9.24 (Rev.CoP17).

To include the remaining species of the genus *Dipteryx* in Appendix II of CITES for reasons of resemblance, in accordance with Article II (2)(b) of the Convention and satisfying Criterion A of Annex 2b of Resolution Conf. 9.24 (Rev.CoP17).

Annotation

New annotation (number to be confirmed): designating logs, sawn wood, veneer sheets, plywood and transformed wood, and seeds (or #17 plus seeds).

B. Proponent

Colombia, European Union and Panama*

C. Supporting statement

1. Taxonomy

1.1 Class: Magnoliopsida

1.2 Order: Fabales

1.3 Family: Leguminosae

1.4 Genus, species or subspecies:

Fourteen species of the genus *Dipteryx* are currently recognised, following a nomenclatural review conducted in 2020 (Carvalho *et al*., 2020a). The species recognised by Carvalho *et al*. (2020a) are as follows: ***D. alata*** Vogel (1837), ***D. casiquiarensis*** (Pittier) G.P. Lewis & Gasson (2000), ***D. charapilla*** (J. F. Macbr.) Ducke (1948), ***D. ferrea*** (Ducke) Ducke (1940), ***D. lacunifera*** Ducke (1948), ***D. magnifica*** (Ducke) Ducke (1940), ***D. micrantha*** Harms (1926), ***D. odorata*** (Aubl.) Forsyth f. (1794), ***D. oleifera*** Benth. (1850), ***D. polyphylla*** Huber (1913), ***D. punctata*** (S.F.Blake) Amshoff (1939), ***D. rosea*** Spruce ex Benth. (1860), ***D. tetraphylla*** Benth. (1860) and ***D. trifoliolata*** (Ducke) Ducke (1940). This proposal follows Carvalho *et al*. (2020a), which is also proposed as the taxonomic

* *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

reference for the genus. Prior to the 2020 review, the last published taxonomic revision of *Dipteryx* was completed 80 years ago (Ducke, 1940).

There is considerable taxonomic uncertainty regarding *Dipteryx*. For example, Royal Botanic Gardens Kew's Plants of the World Online database (POWO, 2021) does not recognise ***D. casiquiarensis*** or ***D. trifoliolata,*** and Botanic Gardens Conservation International's GlobalTreeSearch database does not recognise ***D. casiquiarensis***, ***D. ferrea***, ***D. tetraphylla*** or ***D. trifoliolata*** (BGCI, 2021a). In 2021, Carvalho *et al*. (2021) published a name conservation proposal to rename ***D. oleifera*** under its synonym "*Coumarouna panamensis* (*D. panamensis*)", on the basis that *C. panamensis* and *D. panamensis* are more well-established names for the species, and have been used in numerous national and regional floras, government publications and long-term ecological and socioeconomic studies. A further systematic revision of the genus *Dipteryx* is underway, based on morphological and molecular data (Carvalho *et al*., in prep. Carvalho *et al*., 2020a); this review will reportedly consider ***D. trifoliolata*** to be a synonym of ***D. punctata, D. casiquiarencis*** to be a synonym of ***D. magnifica***, and ***D. tetraphylla*** to be a synonym of ***D. odorata*** (Carvalho pers. comm. to Forest Trends, 2021; 2022).

1.5 Scientific synonyms:

Dipteryx alata: *Coumarouna alata* (Vogel) Kuntze (1891), *Dipteryx pterota* Mart. (1837).

Dipteryx casiquiarensis: *Taralea casiquiarensis* Pittier (1943).

Dipteryx charapilla: *Coumarouna charapilla* J.F.Macbr. (1943).

Dipteryx ferrea: *Coumarouna ferrea* Ducke (1934).

Dipteryx lacunifera: *Coumarouna lacunifera* Ducke (1948).

Dipteryx magnifica: *Coumarouna magnifica* Ducke (1934).

Dipteryx micrantha: *Coumarouna micrantha* (Harms) Ducke (1940).

Dipteryx odorata: *Baryosma tongo* Gaertn. (1790), *Coumarouna odorata* Aubl. (1775), *Heinzia peregrina* J.F.Gmel. (1791).

Dipteryx oleifera: *Coumarouna oleifera* (Benth.) Kuntze (1891), *Coumarouna panamensis* Pittier (1917), *Dipteryx panamensis* (Pittier) Record & Mell (1924), *Oleiocarpon panamense* (Pittier) Dwyer (1965).

Dipteryx polyphylla: *Coumarouna polyphylla* (Huber) Ducke (1922).

Dipteryx punctata: *Coumarouna punctata* S.F.Blake (1924).

Dipteryx rosea: *Coumarouna rosea* (Spruce ex Benth.) Taub. (1891).

Dipteryx tetraphylla: *Coumarouna odorata* var. *tetraphylla* (Spruce ex Benth.) Ducke (1925). *Coumarouna tetraphylla* (Spruce ex Benth.) Taub. (1891).

Dipteryx trifoliolata: *Coumarouna trifoliolata* Ducke (1938).

1.6 Common names: English: Cumaru, Tonka
French: Cumaru, Tonka, Gaiac De Cayenne
Spanish: Cumaru, Shihuahuaco, Almendro, Almendrillo, Charapilla, Sarrapia
Portuguese: Cumarurana, Champanha, Cumaru Ferro, Cumaru-Roxo, Cumaru
Chinese: 香二翅豆木

1.7 Code numbers:

2. Overview

Dipteryx is a taxonomically complex genus encompassing 14 species of large, canopy emergent, slow growing trees, distributed across Central and South America. The genus is targeted for its valuable hardwood timber (often traded under the names cumaru or shihuahuaco), as well as its seeds, known as tonka beans, which are in demand internationally for use in the fragrance, tobacco and food industries. In several range States, *Dipteryx* spp. are also locally important for food, traditional medicine, charcoal, oil, and as shade trees in cocoa agroforestry systems.

The international market for *Dipteryx* timber is expanding, and the genus produces some of the most expensive wood in global trade. Although the principal trade routes for *Dipteryx* timber and tonka beans remain unclear, Brazil, Colombia, Peru and the Plurinational State of Bolivia are major exporters of the timber and the Bolivarian Republic of Venezuela and Brazil appear to be the main producers of tonka beans (mainly from the seeds of *D. punctata* and *D. odorata*), although growing demand for *D. alata* seeds from Bolivia has also been reported. Europe, the United States of America (USA) and the People's Republic of China are key importers of *Dipteryx* timber. Bolivia exported ~3.5 million kg of cumaru to the European Union (EU) in 2019 alone, and exports from Brazil to the USA and EU during 2018-2021 were around 11 million kg and 7 million kg, respectively. The genus *Dipteryx* (traded as shihuahuaco) comprised 80% of all wood exports from Peru in 2015.

Dipteryx spp. face deforestation and habitat degradation throughout their global range, and logging adds significantly to the pressure on wild populations. In addition, trade in seeds collected from wild population has the potential to result in reduced regeneration in *Dipteryx* spp. populations. These threats are known to act synergistically with the genus' intrinsic slow growth and the long time taken to reach reproductive size to bring about population declines, and ongoing harvest of *D. odorata* has been noted to impact viability of some populations. *D. alata* is categorised as globally Vulnerable in the IUCN Red List and is noted to have undergone a 30-50% population decline due to past unsustainable and selective logging and ongoing habitat loss. *D. odorata* and *D. micrantha* are categorised as globally Data Deficient but are considered in decline due to overharvest for timber. An independent, draft assessment of *D. micrantha* provisionally categorised the species as nationally endangered in Peru according to IUCN Red List criteria. *D. oleifera* (syn. *D. panamensis*), assessed as vulnerable in the national red lists of both Colombia and Costa Rica, was listed in CITES Appendix III in 2003 by Costa Rica and in 2007 by Nicaragua due to concerns about the sustainability of trade; the species remains widely exploited in Colombia.

On the basis of population decline and fragmentation due to ongoing intensive timber harvest, as well as biological vulnerability to overharvest due to intrinsic slow growth and late maturation, *D. alata, D. micrantha*, *D. odorata* and *D. oleifera* appear to fulfil the conditions of Criterion B of Annex 2a of Resolution Conf. 9.24 (Rev. CoP17). *Dipteryx* spp. are traded interchangeably for timber in many cases, due to taxonomic uncertainty as well as difficulty distinguishing species from one another based on wood morphological characteristics. Therefore, inclusion of the remaining species of the genus in Appendix II under Criterion A of Annex 2b of Resolution Conf. 9.24 (Rev. CoP17) is also proposed.

Whilst the full scale of international trade in *Dipteryx* seeds (or tonka beans) remains unclear, a new annotation is proposed that would control both the timber commodities currently included under annotation #17, as well as the seeds as a precautionary measure, due to trade in timber being a known threat and understanding that seed harvest and subsequent trade has the potential to act as an additional or even synergistic stressor on the regeneration and long-term viability of *Dipteryx* spp. populations.

3. Species characteristics

3.1 Distribution

Dipteryx is a widespread genus, occurring in numerous countries across Central and South America (POWO, 2021). Although there is some variation in the scientific literature regarding some *Dipteryx* spp. distributions, the genus appears to be native to the Bolivarian Republic of Venezuela (hereafter Venezuela), Brazil, Colombia, Costa Rica, Ecuador, French Guiana[1], Guyana, Honduras, Nicaragua, Panama, Paraguay, Peru, Plurinational State of Bolivia (hereafter Bolivia) and Suriname (BGCI, 2021a; POWO, 2021). The presence of the genus in the Bahamas, Dominica and Trinidad and Tobago as native or introduced populations remains uncertain (Requena Suarez, 2017a).

[1] Overseas department of France

Dipteryx alata occurs in Brazil, Bolivia and Paraguay, and may also occur in Peru (Requena Suarez, 2021). In Brazil, the species occurs in 12 states and is reportedly spread across approximately 72% of the Cerrado ecoregion (Requena Suarez, 2021). An IUCN Red List assessment conducted in 2017 estimated the species' extent of occurrence (EOO) to be 6.92 million km^2, but did not provide an estimated area of occupancy (AOO) (Requena Suarez, 2021).

Dipteryx casiquiarensis: the species' type specimen was reported from Venezuela (Carvalho *et al*., 2020a); however, it is unclear if the species occurs in other range States.

Dipteryx charapilla: according to the 1998 IUCN Red List assessment for the species, *D. charapilla* occurs only in the Loreto Department, Peru (WCMC, 1998b). However, the assessment is marked as "needs updating", and the 2020 Flora of Brazil also reports the species to occur in Acre and Amazonas, Brazil (Carvalho *et al*., 2020b).

Dipteryx ferrea occurs in Bolivia (northern), Brazil (northern) and Peru (Garcia-Davila *et al*., 2020; POWO, 2021). However, Honorio Coronado *et al*. (2020) report this species in Bolivia and Peru only.

Dipteryx lacunifera is a Brazilian endemic (BGCI, 2021a; POWO, 2021). The 2018 IUCN Red List assessment for the species gives an estimated EOO of 217 062 km^2 but an estimated AOO of only 176 km^2 (BGCI and IUCN SSC GTSG 2019a).

Dipteryx magnifica: according to POWO (2021), the species occurs in Brazil, Colombia and Venezuela. BGCI (2021a) conversely considers Ecuador, Peru and Venezuela to be the species' range States. However, taxonomic research indicates that only three species of *Dipteryx* occur in Peru: *D. charapilla*, *D. ferrea* and *D. micrantha* (Garcia-Davila *et al*., 2020). In Venezuela, the species is reported to occur in the southern state of Amazonas (Funk *et al*., 2007).

Dipteryx micrantha is reported to occur in Brazil (north), Colombia, Ecuador and Peru (Carvalho, pers. comm. to Forest Trends, 2021). However, other sources also list Bolivia as a range State (Requena Suarez, 2017b; BGCI, 2021a; POWO, 2021), and BGCI (2021a) does not consider the species to occur in Colombia. The IUCN Red List assessment of 2017 estimates an EOO of 2 258 505 km^2 for the species (Requena Suarez, 2017b).

Dipteryx odorata is considered native to Brazil (north, northeast and west-central), French Guiana, Guyana, Suriname and Venezuela (Carvalho, pers. comm. to Forest Trends, 2021). In Venezuela, the species occurs in the states of Amazonas (south), Bolivar (east-central) and Delta Amacuro (northeast) (Funk *et al*., 2007). The 2017 IUCN Red List assessment for the species additionally lists Bolivia, Colombia and Honduras as range States, but does not include Suriname (Requena Suarez, 2017a). The assessment also notes uncertain presence or introductions of *D. odorata* in the Bahamas, Dominica and Trinidad and Tobago (Requena Suarez, 2017a). POWO (2021) also considers Colombia to be a range State, and BGCI (2021a) additionally lists Bolivia, Colombia and Trinidad and Tobago as range States. *D. odorata* was also included in a 2012 list of medicinal plants of Trinidad and Tobago (Barclay, 2012). Although both POWO (2021) and BGCI (2021a) list Peru as a range State, recent taxonomic research (Aldana Gomero *et al*., 2016; Garcia-Davila *et al*., 2020) indicates that *D. odorata* does not occur in Peru. The species' EOO is estimated as 9 670 054 km^2 (Requena Suarez, 2017a).

***Dipteryx oleifera*:** the latest available information on this species, provided by Zamora and Carvalho (pers. comm. to Forest Trends, 2021), gives the species' distribution as Colombia, Costa Rica, Nicaragua and Panama. Other sources additionally list Ecuador and Honduras as range States (BGCI, 2021a; Condit, 2021; POWO, 2021). The species was reported to have a large distribution, with an estimated EOO of 541 000 km^2 (Condit, 2021), although the figures given for EOO and AOO are the same, which seems unlikely for a widespread species. Furthermore, the EOO would be reduced if the species was confirmed not to occur in Ecuador and Honduras.

Dipteryx polyphylla occurs in Brazil and Colombia (BGCI, 2021a; Hills, 2021; POWO, 2021). An IUCN Red List assessment for the species conducted in 2020 estimates an EOO of 690 946 km^2 and a minimum AOO of 100 km^2 (Hills, 2021).

Dipteryx punctata is native to Brazil, Colombia, French Guiana, Guyana, Suriname and Venezuela (BGCI and IUCN SSC GTSG, 2019b; BGCI, 2021a; POWO, 2021). In Venezuela, the species occurs in the states of Amazonas (south) and Bolivar (east-central) (Funk *et al*., 2007).

Dipteryx rosea is stated to be native to Brazil, Peru and Venezuela by both BGCI (2021a) and POWO (2021). In Venezuela, the species occurs in the states of Amazonas (south) and Bolivar (east-central) (Funk *et al*., 2007). POWO (2021) and Ruiz *et al.* (2015) additionally list Colombia as a range State.

Dipteryx tetraphylla is reported to be endemic to northern Brazil (POWO, 2021).

Dipteryx trifoliolata: the species' type specimen was reported from Brazil (Carvalho *et al*., 2020a). However, it is unclear if the species occurs in other range States, and according to Carvalho (pers. comm. to Forest Trends, 2021), *D. trifoliolata* may actually be a synonym of ***D. punctata***.

3.2 Habitat

Dipteryx species are found in tropical rain forest, seasonally dry forest and woodland (POWO, 2021). ***D. alata*** is found in savanna (Requena Suarez, 2021), whereas ***D. micrantha*** and ***D. odorata*** are both tropical rainforest species and are found in old growth forest throughout the Amazon basin (Requena Suarez, 2017a; 2017b). While ***D. micrantha*** can be found from floodplain to upland forest with an upper elevation limit of 800 meters (Requena Suarez, 2017b), ***D. odorata*** grows best on well-drained gravelly or sandy sites at an upper elevation limit of 500 m (Requena Suarez, 2017a). ***D. oleifera*** grows in humid and very humid rainforests in the Atlantic zone from Nicaragua to Colombia at elevations between 0-1300 m (Fleisswasser, 2014), in areas with mean annual temperatures of 24-30°C and mean annual precipitation of 3500-5500 mm (Vozzo, 2002 in Schmidt, 2009).

3.3 Biological characteristics

Dipteryx is a widespread neotropical canopy-emergent genus of trees, growing up to 150 cm in diameter at breast height (DBH) and 35-60 m in height (Terborgh and Wright, 1994; Reynel *et al.,* 2003 in Putzel *et al.,* 2011). The genus is slow growing, with species taking an estimated average of 46-177 years to reach 30 cm in diameter (Clark and Clark, 2001), the size at which individuals of ***D. oleifera*** were observed to reach reproductive maturity and begin bearing fruit (Hanson, pers. obs. in Hanson *et al*., 2006). However, one study reported a shorter maturation time and productive lifespan, of six years and 50 years respectively, for ***D. alata*** in agroforestry systems (Carvalho 1994 in Vennetier *et al*. 2012). *Dipteryx* spp. are reported to produce fruit supra-annually (Pinto *et al*., 2008; Pérez and Souto, 2011). A long-term phenological study of ***D. odorata*** over the period 1974-2000 at two Brazilian Amazon study sites found that flowering occurred annually but production of mature fruits occurred at intervals of 1-7 years (Pinto *et al*., 2008). Similarly, *Dipteryx* spp. (identified as ***D. odorata*** or possibly ***D. punctata***) in southern Venezuela were reported to fruit at 3-year intervals (Pérez and Souto, 2011). Average fruit production per tree has been reported to be 150 kg in ***D. alata*** (Teixeira and Zuniga, 2016) and 10-20 kg in ***D. odorata*** (or possibly ***D. punctata***) (Pérez and Souto, 2011). In addition, only a "small percentage" of mature trees may produce fruit in a given year (Herrero-Jáuregui *et al*., 2011).

D. alata can grow to 50 m in height and 1.7 m in diameter (Requena Suarez, 2021). *D. alata* is pollinated by bees, and its fruits are dispersed by mammals, including bats and monkeys (Collevatti *et al*, 2010). Habitat fragmentation has been noted to hinder mammalian seed dispersal of *D. alata* (Requena Suarez, 2021).

D. micrantha can reach up to 1.5 m in diameter and up to 40 m in height with buttress roots up to 2 m (Romo *et al*., 2019). The species can regenerate in both late-successional and mature forest and a variety of habitats, from floodplain to upland forests (Romo *et al.,* 2004a). While shade tolerant at seedling and sapling phases, the species requires light to grow into the larger size classes (Romo *et al*., 2004a). Medium sized trees (poles, juveniles) have been found to occur at low densities in natural unlogged conditions compared to other size classes (Romo *et al.,* 2004a). A study on growth rings of *D. micrantha* carried out by Jenkins (2009) in the Madre de Dios region of Peru found an average annual growth rate of 2.77 mm over the first 100 rings/years and 0.86 mm after 300 rings/years, indicating extremely slow growth similar to other tree species with very hard, dense wood. *D. micrantha* is reported to reach reproductive maturity at a minimum of 40 cm DBH (Romo, pers. obs. in Romo *et al*., 2004a). The species can reportedly live for over a thousand years (Chambers *et al.,* 1998).

D. odorata is a light-demanding species that reaches up to 25-40 m in height, with a trunk diameter of about 1 m. The species occurs in very low densities. Vinson *et al*. (2015) reported that the species reaches fruiting size (reproductive maturity) at a minimum of 39 cm DBH. In Pará (Brazil), the species flowers from August to October, and fruits from April to July (ITTO, 2017 in Requena Suarez, 2017a). Its flowers are pollinated by insects and hummingbirds and its fruit is dispersed mainly by bats (Vinson *et al.,* 2015). A maximum adult age of 1200 years has been estimated for the species (Chambers *et al*., 1998).

D. oleifera grows up to 40 m in height. Maximum adult ages of 330 years have been estimated for *D. oleifera* (Clark and Clark, 1992). The species is extremely slow growing in natural forest conditions (Clark and Clark, 1992). *D. oleifera* fruits are dispersed by large frugivorous bats, which drop the seeds at roosting sites after feeding on the fruit pulp, and by terrestrial mammals including agoutis and squirrels, which hoard and bury the seeds (Ruiz, 2008). In Panama, the average dispersal distance of *D. oleifera* seeds by rodents was <3 m from the mother tree, though some were moved >10 m (Dittel *et al*., 2015).

3.4 Morphological characteristics

Dipteryx spp. have flattened leaf rachis, asymmetrical leaflets, drupaceous fruits, and a unique papilionate flower architecture with petals strongly differentiated into standard, wings, and keel, and a calyx with expanded, wing-like lateral lobes (Polhill and Raven, 1981 in Carvalho *et al.,* 2020a).

D. micrantha has large buttresses and a distinctive salmon-coloured trunk (Cintra and Horna, 1997).

D. odorata has smooth grey bark and alternate pinnate glossy dark green leaves, with flowers that are pale white with wings and a keel petal that is pink to whitish-pink. The species has a small round crown and black, wrinkled, fragrant seeds. The fresh heartwood is reddish brown or purplish brown with light yellowish-brown or purplish streaks; upon exposure it gradually becomes uniform light brown or yellowish brown. The sapwood is a distinct, narrow, yellowish brown (USDA Forest Service, n.d.).

D. oleifera fruits are one seeded drupes of 4 to 6 cm length and 3 cm width. Seeds are 3 to 3.5 cm long and 1.2 to 1.5 cm wide and surrounded by a brown seedcoat. The flowering period starts in July and ends in February, while the fruiting period is from September to April (Stevens *et al.,* 2001 in Fleisswasser, 2014).

3.5 Role of the species in its ecosystem

D. alata, ***D. micrantha***, ***D. odorata*** and ***D. oleifera*** provide nesting sites for threatened birds. Peru's 2018 Red List of Threatened Wildlife states that the logging of *Dipteryx* spp. in Peru had resulted in the loss of nests and juveniles and a reduced availability of nesting sites for the nationally vulnerable and globally Near Threatened Harpy eagle (*Harpia harpyja*) (SERFOR, 2018). Cavities in the trunks of ***D. micrantha*** trees are used as nest sites by the CITES Appendix I-listed Scarlet macaw (*Ara macao*) and other threatened macaw species such as the Red and Green macaw (*Ara chloroptera*), with birds returning year after year (Brightsmith, 2005). In addition, ***D. micrantha*** is an important nesting tree species for Peru's nationally vulnerable Crested eagle (*Morphnus guianensis)* (Begazu, 2021). Similarly, the decline in ***D. oleifera*** in Costa Rica was considered the cause of the decline in the Critically Endangered Great Green macaw (*Ara ambiguus*) in that country (Bjork and Powell 1995; Chassot and Monge, 2002). Despite planting schemes of *Dipteryx* trees in Costa Rica that can produce fruiting trees, the large adult trees with useable cavities for macaw nesting are irreplaceable, as they take hundreds of years to grow (Brightsmith, 2005). In Nicaragua, ***D. oleifera*** was also noted to provide an estimated 80% of the diet of *A. ambiguus* and 90% of its nesting sites (Government of Nicaragua, 2006a).

The fruit, seeds and flowers of *Dipteryx* spp. are important food sources for numerous mammal, bird and insect species, including bats, parrots, agoutis, peccaries, deer, tapir, hummingbirds and bees (Terborgh and Wright, 1994; Romo *et al.,* 2004b; Government of Nicaragua, 2006a; Vinson *et al.,* 2015). ***D. oleifera*** is classified as a keystone species because it fruits during a time of food scarcity for frugivorous animals (de Stevens and Putz, 1984; Hanson *et al.,* 2006). In addition, the broad buttresses of *Dipteryx* spp. make these trees ecologically important both for forest structural integrity while standing (Clark and Clark, 2001) and for the large gaps created when they fall, facilitating successional forest growth (Romo *et al.,* 2004a). *Dipteryx* spp. also play an important role in climate

change mitigation in Amazonian forests, due to their high wood density and carbon storage capacity (Goodman *et al.,* 2012; 2014).

4. Status and trends

4.1 Habitat trends

Dipteryx spp. are found in the Amazonian rainforests of Brazil and Peru (Requena Suarez, 2017b; Romo *et al*., 2019), the savannas of Brazil, Bolivia and Paraguay (POWO, 2021), and the rainforests of Colombia, Costa Rica, Nicaragua and Panama (Fleisswasser, 2014). All of these habitats are increasingly threatened by deforestation and forest degradation (FAO, 2020; Vancutsem *et al*., 2021; see Section 4.5), logging (Antongiovanni *et al.,* 2020), land conversion to agriculture (Mantovani and Pereira 1998; Fleisswasser, 2014; Antongiovanni *et al.,* 2020) and climate change (IPCC, 2019; Marengo *et al.*, 2018).

The rainforests of Central America for example have been subject to significant clearance for fruit plantations and pastureland (Fleisswasser, 2014). Major forest and woodland habitats in Brazil, in which at least 11 of the 14 recognised *Dipteryx* spp. occur (Carvalho *et al*., 2020a; BGCI, 2021a; POWO, 2021, see Section 3), are in decline (WWF, 2021). The rate of destruction of the Amazon region had declined in Brazil between 2004-2012 but, as has been widely documented, has begun to increase sharply, particularly since 2019 (see Section 4.5). In the Xingu basin in the state of Pará, for example, 196 trees were reportedly felled per minute in March and April 2021, a 40% increase over the same period in 2020 (RedeXingu, 2021). Seasonally dry forest, including the Caatinga shrub and thornforest ecoregion, is increasingly threatened by grazing, logging and fire (Antongiovanni *et al.,* 2020).

The savannas of Brazil, Bolivia, and Paraguay, including the Cerrado ecoregion in which ***D. alata*** occurs, are also under threat (Espírito-Santo *et al*., 2016). Around 67% of the Cerrado has been already either completely converted for agriculture or modified in a major way (Mantovani and Pereira 1998).

4.2 Population size

There are no population data for any species of *Dipteryx* across their entire range. However, while there is little information regarding the current number of mature individuals, the growth of these species is very slow and they generally occur at low densities (Vinson *et al.,* 2015).

D. alata was reported to be “abundant and well preserved” in eastern Bolivia (Moraes pers. comm. in Requena Suarez, 2021), and to occupy approximately 72% of the Brazilian Cerrado ecoregion (Requena Suarez, 2021). However, the global population of ***D. alata*** was also suspected to have undergone a 30-50% population decline over the past three generations, mainly as a result of habitat conversion in the Cerrado and exploitation for timber (Requena Suarez, 2021).

All density estimates that could be located for ***D. micrantha*** are from Peru. Data from 356 permanent forest plots in primary forest across a number of locations in the Peruvian Amazon, covering a total of 165 ha, recorded a total of 66 ***D. micrantha*** individuals (equivalent to 0.19 individuals per ha) (Honorio Coronado *et al.* 2018), which is similar to the estimated 0.29 individuals per ha with a DBH of >51 cm in Madre de Dios and 0.2 individuals per ha in Ucayali recorded by Romo *et al.* (2019); these are the two of the main areas of occurrence in the country and where many logging concessions are located. However, Espinosa and Valle (2020) recorded a higher population density of 0.71 individuals per ha in a forest conservation concession in Madre de Dios, and the species was found to be “abundant” at Cocha Cashu Biological Station (also in Madre de Dios) (1.75 individuals per ha), and at only slightly lower abundance in the surrounding region (1.25 individuals per ha) (Diaz-Martin *et al*., 2014).

A study carried out in Brazil in 2012 in three forest inventories that practised reduced impact logging (RIL) noted that ***D. odorata*** displayed a very low density of adults (classed as trees of >45 cm DBH) of under 0.15 trees per ha in all three locations (Herrero-Jáuregui *et al.,* 2012). Within Tapajós National Forest, Brazil, the density of large mature ***D. odorata*** trees (≥45 cm DBH) was also found to be low, at 0.12 individuals per ha (Diaz-Martin *et al*., 2014).

D. oleifera was reported to occur at a mean density of approximately 1.08 trees per ha in central Panama (Condit, 2021).

4.3 Population structure

Information on the population structure of *Dipteryx* spp. is scarce. According to Espinosa and Valle (2020) ***D. micrantha*** individuals recorded in 2019 in the Madre de Dios forest conservation concession in the Las Piedras River basin, Peru, were all extremely old (the average DBH was 87.66 cm, meaning that the average age of the trees was estimated at 684.8 years), and levels of regeneration and recruitment were very low: only 0.06 juvenile trees (10-40 cm diameter) were found per ha and there was a total absence of saplings of 4-10 cm in diameter. The authors noted that the low numbers of seedlings and absence of saplings indicated that recruitment levels were insufficient for the species' long-term survival in the Madre de Dios conservation concession (Espinosa and Valle, 2020).

D. odorata was noted to exhibit an "inverted J-shaped" distribution throughout its range, with few adult trees in large size classes and higher numbers of juveniles (Requena Suarez, 2017a). According to an inventory of *D. odorata* in Brazil where RIL was practised, all large-diameter (>90 cm DBH) trees had been extracted (Herrero-Jáuregui *et al.,* 2012). The authors noted that the negative impact of RIL on reproduction and regeneration processes of the species may reduce the already relatively low density of saplings in future (Herrero-Jáuregui *et al.,* 2012). The Brazilian study additionally observed impacts of seed (tonka bean) harvest on *D. odorata* population structure: very few individuals in smaller adult size classes (15-45 cm DBH) in areas where collection of *D. odorata* seeds takes place, which the authors attributed to intensive seed collecting in the 1940s (Amorim, 2000 in Herrero-Jáuregui *et al.,* 2012) and a lack of incorporation of new trees since that time (Herrero-Jáuregui *et al.,* 2012). The authors concluded that unsustainable seed collection could negatively impact ***D. odorata*** population viability (Herrero-Jáuregui *et al.,* 2012). Similarly, Vieira *et al*. (2021) found few adult *D. odorata* in the Tapajós National Forest Mixed Co-operative in western Pará State, which was considered likely caused by a boom in seed collection in the 1940s affecting recruitment.

A study of regeneration and recruitment of *Dipteryx* spp. in Ucayali and Loreto, Peru following logging activity found that initial post-logging conditions enhanced recruitment of residual seedlings at recently logged sites (Putzel *et al*., 2011). However, the authors noted that the long-term re-establishment of mature *Dipteryx* spp. trees after logging was not assured and, over time, logging of *Dipteryx* spp. was likely to "reduce or eliminate seed production and future regeneration" (Putzel *et al*., 2011). As observed in other emergent tree species (Carneiro *et al.,* 2011), a lack of large trees can impact pollination (Vinson, 2009 in Herrero-Jáuregui *et al.,* 2012), seed dispersal (Jansen and Zuidema, 2001), genetic diversity (Jennings *et al.,* 2001) and reproductive capacity.

4.4 Population trends

There are little available data on population status and trends of the genus as a whole, but the global populations of several species were considered to be declining: namely ***D. micrantha*** (Requena Suarez, 2017b), ***D. odorata*** (Requena Suarez, 2017a), and ***D. alata*** (Requena Suarez, 2021). Of the 14 currently accepted species of *Dipteryx* (Carvalho *et al*., 2020a), eight have been globally assessed by the IUCN Red List: ***D. alata*** (WCMC 1998a; Requena Suarez, 2021), ***D. charapilla*** (WCMC 1998b), ***D. lacunifera*** (BGCI and IUCN SSC, 2019a), ***D. micrantha*** (Requena Suarez, 2017b), ***D. odorata*** (Requena Suarez, 2017a), ***D. oleifera*** (Condit, 2021), ***D. polyphylla*** (Hills, 2021) and ***D. punctata*** (BGCI and IUCN SSC, 2019b). According to Hills (*in litt.* to UNEP-WCMC, 2021), BGCI has assigned ***D. rosea***, and intends to assign ***D. ferrea*** and ***D. magnifica***, to species/genus experts for IUCN Red List assessment in 2022.

D. alata was re-assessed as globally Vulnerable in the IUCN Red List in 2017, based on substantial population declines driven by habitat loss and associated genetic isolation of subpopulations, notably in the Brazilian Cerrado, as well as harvest for timber (Requena Suarez, 2021). A previous IUCN Red List assessment, in 1998, categorised the species as Vulnerable on the basis of loss of habitat from conversion to agriculture as well as "massive" population decline as a result of timber and medicinal seed harvest (WCMC, 1998a). In 2012, *D. alata* was categorised as nationally least concern in Brazil, on the basis of a large distribution and apparently stable population (CNCFlora, 2012). The CITES MA of Brazil (*in litt*. to European Commission, 2022) stated that none of the Brazilian *Dipteryx* spp. are listed or proposed for listing in the country's national red list, and there is

no indication of "any level of threat to the genus *Dipteryx* in the Brazilian territory". However, the 2012 Brazilian national assessment noted that *D. alata* is valued for its timber, and that logging could reduce some subpopulations "in the near future" (CNCFlora, 2012).

D. odorata* and *D. micrantha were both categorised as globally Data Deficient in the IUCN Red List in 2017 due to a lack of population data across their range and ongoing taxonomic uncertainties (Requena Suarez 2017a; 2017b). Populations of both species were considered to be in decline, with selective logging posing a "major threat" and the species' intrinsic slow growth impeding regeneration after harvest (Requena Suarez 2017a; 2017b). The assessments noted that the rate of decline of both species was unknown, resulting in their categorisation as Data Deficient rather than a threatened category (Requena Suarez 2017a; 2017b). The assessment for ***D. micrantha*** also considered deforestation and habitat degradation to be major threats to the species (Requena Suarez 2017b). Both ***D. micrantha* and *D. odorata*** were considered "high risk" species facing illegal and/or unsustainable harvest in Peru and Bolivia, respectively, in WWF's Global Forest and Trade Network 2015 country profiles report (WWF, 2015). Vinson *et al.* (2015) reported that under current Brazilian forest management regulations, ***D. odorata*** could not be sustainably logged, as a sustainable scenario would require increasing the minimum cutting DBH from 50 cm to 100 cm over 30-year logging cycles. Collection of ***D. odorata*** seeds was also considered a threat to this species in the Brazilian Amazon, as collection led to depletion of young individuals (Herrero-Jáuregui *et al*., 2012). The authors noted that, if continued, high collection intensity could cause the local extinction of some populations (Herrero-Jáuregui *et al*., 2012). An independent, draft assessment of ***D. micrantha*** provisionally categorised the species as nationally endangered in Peru according to IUCN Red List criteria (Romo *et al*. *in litt*. to Forest Trends, 2022). The assessment used a Forest Data Connect (2022) national distribution estimate of 22 516 km^2 for ***D. micrantha***, in combination with an average density estimate of 0.15 mature trees (>51 cm DBH) per ha based on ForestPlot.net data to calculate a pre-exploitation population size for the species in Peru; the assessment then used timber harvest data from MINAGRI-SERFOR forest yearbooks to estimate a population decline of 33% over the period 2000-2020, and a potential 66% decline by 2036 (Romo *et al*. *in litt*. to Forest Trends, 2022). The assessment has not been validated by the Peruvian government, but was submitted to SERFOR for review in May 2022 (Romo *et al*. *in litt*. to Forest Trends, 2022).

D. oleifera has been assessed as nationally vulnerable in the Red Data Books of Colombia (Cardenas and Salinas, 2007) and Costa Rica (Estrada Chavarría *et al*., 2005 in Fliesswasser, 2014), as well as in Panama's 2016 list of threatened species of fauna and flora (Government of Panama, 2016a). Approximately 40% of the Colombian population of *D. oleifera* was considered to have been "heavily exploited for timber", leading to the species' national categorisation (Cardenas and Salinas, 2007). In Costa Rica, the potential distribution of *D. oleifera*, based on known occurrence points, was estimated at approximately 10 180 km^2; however, the species' assessors noted that less than half of this area had remaining forest cover suitable for the species (Estrada Chavarría *et al*., 2005 in Fliesswasser, 2014). Slash and burn agriculture was additionally considered to threaten the survival of *D. oleifera* (under the synonym *D. panamensis*) in Nicaragua (Government of Nicaragua, 2006a). Globally, the species' population was considered to have been "reduced" and fragmented by exploitation and clearance of forest for agriculture across its range, with the species considered a "conservation priority" (Hanson *et al*., 2006). In 2020, *D. oleifera* was globally assessed in the IUCN Red List as Least Concern based on its very large EOO (541 000 km^2), and a lack of any current or forecasted "major threats" (Condit, 2021). However, the global assessment lacks critical data and information on trade threats, including that the species was listed in CITES Appendix III (under its synonym *D. panamensis*) by Costa Rica in 2003 and Nicaragua in 2007 due to concerns about exploitation for its timber.

D. charapilla was assessed as globally Vulnerable in the IUCN Red List in 1998, apparently based on the species (at the time) being known only from its type locality in Loreto Department, Peru (WCMC, 1998b). The assessment provides very limited information, and is flagged as "needs updating" (WCMC, 1998b). According to Hills (*in litt.* to UNEP-WCMC, 2021), BGCI intends to assign *D. charapilla* for IUCN Red List re-assessment in 2022. More recently, Garcia-Davila *et al.* (2020) recommended that the felling of *D. charapilla* should be prohibited in Loreto in order to preserve the presence of the species in Peru. Since the species' occurrence in Brazil is uncertain and it may be a Peruvian endemic (see Section 3.1), this recommendation from Garcia-Davila *et al.* (2020) seems to indicate that the global population of *D. charapilla* may be at significant risk.

D. ferrea was recently provisionally categorised as critically endangered in Peru, based on past and projected future population declines as a result of logging (Romo *et al*. *in litt*. to Forest Trends, 2022). The assessment was conducted by independent researchers and has not been validated by the

Peruvian government, but was submitted to SERFOR for review in May 2022 (Romo *et al*. *in litt*. to Forest Trends, 2022).

D. lacunifera and D. punctata were both categorised as globally Least Concern in 2018, on the basis of wide distributions, large and stable populations, and a lack of any identified current or future major threats (BGCI and IUCN SSC, 2019a; BGCI and IUCN SSC, 2019b). However, neither assessment includes any population data, and in the case of ***D. lacunifera*** the lack of threats appears to be based solely on a lack of national or previous global threat assessments for the species in BGCI's ThreatSearch database (BGCI, 2021b). BGCI ThreatSearch lists a previous global status assessment of "not threatened" for ***D. punctata*** conducted by Royal Botanic Gardens, Kew, in 2010 (apparently not using IUCN Red List categories and criteria) (BGCI, 2021b), but no further information appears to be available to support either the 2018 or 2010 assessment.

D. polyphylla was assessed as globally Near Threatened in 2020, based on loss of the species' Amazon rainforest habitat driven by development and conversion to agriculture (Hills, 2021). Exploitation for timber was also considered a "possible threat" to the species (Hills, 2021).

4.5 Geographic trends

Many of the range States of *Dipteryx* spp. have recently experienced substantial deforestation and forest degradation (FAO, 2020; Vancutsem *et al.*, 2021a; Vancutsem *et al.*, 2021b). The FAO's Global Forest Resources Assessment (FRA) for 2020 included three *Dipteryx* spp. range States (Brazil, Bolivia and Paraguay) amongst the ten countries with the highest average annual net loss of forest area over the period 2010-2020, with an annual net loss of 0.30%, 0.43% and 1.93%, respectively (FAO, 2020). The assessment found that Brazil had the highest annual net loss of forest area in any country assessed, with an average net loss of 1496 ha per year (FAO, 2020). Moreover, Brazil accounted for approximately 7% of global wood removals in 2018, the fourth highest percentage of any individual country, and annual deforestation rates in the Amazon increased significantly in 2016 to 3.9 million ha per year (FAO 2020, Vancutsem *et al.*, 2021b). The Cerrado biome in Brazil is experiencing similar declines, with a net loss of 9520 km^2 between 2000-2015 and an annual net loss of 1.2% per year due to land conversion (Espírito-Santo *et al*., 2016). Tropical moist forest degradation is also particularly prevalent in Nicaragua, where 65.8% of forests have been degraded 1990-2019, the second highest proportion of forest loss of previously undisturbed forest (that is, forest unaffected by deforestation or degradation) in the Americas (Vancutsem *et al.*, 2021b). Over the 30-year period 1990-2019, Brazil, Bolivia, Colombia, Peru and Venezuela were found to have undergone total declines in area of undisturbed tropical moist forest of 24.9%, 34%, 21.6%, 11.8% and 18.6%, respectively (Vancutsem *et al.*, 2021b). Additionally, disturbance rates (that is, natural and anthropogenic degradation or deforestation) in Colombia, Venezuela, Nicaragua and Ecuador have increased significantly 2000-2014 compared to 1990-1999, by 0.23 million ha per year, 0.17 million ha per year, 0.08 million ha per year and 0.09 million ha per year, respectively (Vancutsem *et al.*, 2021b).

5. Threats

Dipteryx spp. are threatened by targeted logging (Requena Suarez 2017a; 2017b; Garcia-Davila *et al.* 2020) and in some regions also illegal harvest (Government of Nicaragua, 2006a; WWF, 2015). The timber of several species is in great demand due to their dense, hard wood and this has encouraged logging in forests outside timber production areas, causing significant degradation of the ecosystem (Garcia-Davila *et al.,* 2020). Since *Dipteryx* spp. are intrinsically very slow growing, taking an estimated 47-177 years to reach 30 cm DBH (Clark and Clark, 2001) (a size observed to be compatible with reproductive maturity (Hanson, pers. obs. in Hanson *et al*., 2006; Vinson *et al*. 2015)), the targeted extraction of large seed trees poses a major threat to population regeneration (Requena Suarez 2017a; 2017b). Furthermore, previous confusion regarding the taxonomy and distribution of some *Dipteryx* spp., such as ***D. charapilla*** and ***D. odorata*** in Peru (Aldana Gomero *et al*., 2016; Garcia-Davila *et al*., 2020, see Section 3.1), compounded by the difficulty in differentiating the timber to species level (Koch, pers. comm. to Forest Trends, 2021, see Section 9) has led to some species being mistakenly traded as others (Garcia-Davila *et al*., 2020). Populations of rarer species could thus become threatened if they are erroneously extracted under the name of a more widespread species within the genus.

Several *Dipteryx* spp. are also subject to intensive seed collection for the national and international markets (Kermath *et al.*, 2014; Bovell-Benjamin and Roberts, 2016; Government of Venezuela, 2020). Historical seed collection in combination with logging was considered to have caused major population

declines in ***D. alata*** (WCMC, 1998a), and ongoing seed collection is considered to threaten survival of some ***D. odorata*** subpopulations in Brazil (Herrero-Jáuregui *et al*., 2012).

The ecosystems in which all 14 species of *Dipteryx* occur have become increasingly threatened by habitat degradation and deforestation (Leisher *et al.,* 2013; Antongiovanni *et al.,* 2020). Habitat loss caused by conversion of forest, woodland and savanna for agriculture constitutes a serious threat to many *Dipteryx* spp. (WCMC, 1998a; Hanson *et al*., 2006; Collevatti *et al*., 2013; Fleisswasser, 2014). A study of ***D. alata*** gene flow in Brazil in 2014 found that deforestation had led to fragmentation of subpopulations within forest fragments and pastures, leading to isolation of individuals and higher levels of inbreeding than seen in higher density populations (Tambarussi *et al*., 2017). The authors noted that inbreeding depression can result in reduced seed germination and seedling survival rates, which may impact the species' regeneration and long-term survival (Tambarussi *et al*., 2017). An earlier study noted that the global ***D. alata*** population has intrinsic low genetic diversity due to historic range contractions during the Pleistocene period, meaning that the species is less resilient to ongoing (modern) population fragmentation resulting from habitat loss, such as in the Brazilian Cerrado (Collevatti *et al*., 2013).

Only eight *Dipteryx* spp. have been globally assessed against IUCN Red List categories and criteria (see Section 4.4). Of those that have been assessed, two (***D. alata*** and ***D. charapilla***) were considered Vulnerable (WCMC, 1998a; WCMC, 1998b), one (***D. polyphylla***) was considered Near Threatened, and two were assessed as Data Deficient but in decline (***D. micrantha*** and ***D. odorata***, Requena Suarez 2017a; 2017b). However, even among the three species considered globally Least Concern, two assessments (***D. lacunifera*** and ***D. punctata***, BGCI and IUCN SSC, 2019a; BGCI and IUCN SSC, 2019b) were data poor and the third species, ***D. oleifera***, is considered nationally vulnerable in several range States (Estrada Chavarría *et al*., 2005 in Fliesswasser, 2014; Cardenas and Salinas, 2007; Government of Panama, 2016a).

6. Utilization and trade

6.1 National utilization

Seeds of *Dipteryx* spp. (in particular ***D. odorata***, ***D. oleifera***, ***D. alata***, and ***D. punctata***) are used for food, medicine and oil locally (Bovell-Benjamin and Roberts, 2016; da Silva *et al.*, 2010; Vennetier *et al.* 2012), and the timber is used for tools and charcoal (Putzel *et al.*, 2013; Kermath *et al.*, 2014). ***D. oleifera*** was noted to be used to shade cacao (*Theobroma cacao*) (Kermath *et al.*, 2014). ***D. alata*** seeds were noted to be commercially important in small to medium sized food industries of central Brazil (Collevatti *et al*., 2010) and Bolivia (Vennetier *et al.* 2012; Pérez-Cruz and Villarroel, 2020), and ***D. odorata*** seeds were noted to be used in the cosmetics and perfume industries in Brazil (da Silva *et al*., 2010). According to de Lima (pers. comm. to Forest Trends, 2021) and Carvalho (pers. comm. to Forest Trends, 2021), ***D. punctata*** is the species most used for tonka bean harvest, mainly in Venezuela. However, Pérez and Souto (2011) state that it is unclear whether ***D. odorata*** or ***D. punctata*** is the predominantly harvested tonka bean species in the country, and Fernández (pers. comm. 2010 in Pérez and Souto, 2011) identified ***D. odorata*** as the main tonka bean species in the Lower Caura River Basin region of southern Venezuela. This region was stated as supplying "the majority" of Venezuela's tonka beans (Pérez and Souto, 2011).

6.2 Legal trade

Dipteryx species are prized by the timber industry for their hard, rot resistant wood, and are widely used for decking and flooring (Putzel *et al.*, 2008; Putzel *et al.*, 2011). According to the latest ITTO market report, cumaru decking has a market value of USD 1204-1237/m^3 in the United States of America (USA) and USD 1093-1119/m^3 in Asia, making it one of the most expensive timbers on the global market (ITTO, 2021). While the principal trade routes for this commodity remain unclear, with no comparable export or import figures available, large volumes of *Dipteryx* timber have been noted to have been exported from Brazil (Fritz *et al.*, 2020; Panjiva, 2021a), Bolivia (Norman and Rodriguez Zunino, 2021), Colombia, and Peru (Putzel pers. comm. in Romo *et al.,* 2019; Global Witness, 2019), and to a lesser extent from Guyana, Panama and Nicaragua (see Table 2). Europe, the USA and the People's Republic of China (hereafter China) have all been identified as major importers of *Dipteryx* timber (Norman and Rodriguez Zunino, 2021; Panjiva, 2021a; Putzel *et al.*, 2008, 2011; SUNAT, 2021).

The seeds of several species of *Dipteryx,* known *inter alia* as tonka beans, cumaru nuts and baru nut/almonds, are used by the food, flavouring and fragrance industries (Bovell-Benjamin and

Roberts, 2016); however, no global trade figures could be found to identify the main international exporters or importers of this commodity. An article on the history of trade in ***D. odorata*** and ***D. punctata*** by the Venezuelan Government noted that the largest "cultivation areas" for these species for the production of tonka beans were located in the south of Venezuela, the north of Brazil, Guyana and Trinidad and Tobago (Government of Venezuela, 2020). Carvalho (pers. comm. to Forest Trends, 2021) reported the main producer of tonka beans to be Venezuela, followed by Brazil.

Available country-level export figures for *Dipteryx* timber and seeds are given below:

Bolivia: A 2021 Forest Trends report noted that cumaru (*Dipteryx* spp.) made up 26% of Bolivia's exports of wooden flooring (which is reported to be the country's most lucrative timber product type), by volume in 2019 (Norman and Rodriguez Zunino, 2021). Europe (EU and EFTA countries) was considered the largest export destination for the country's wooden flooring, with exports to the region increasing by 200% between 2016 and 2019 (Norman and Rodriguez Zunino, 2021). Bolivia exported 3 539 994 kg of cumaru (not identified to species) to the EU and EFTA in 2019, of which 90% was imported by France, Germany, the Netherlands and Belgium (Norman and Rodriguez Zunino, 2021). The Forest Trends report further noted that, in 2019, approximately 35% of Bolivia's wooden flooring exports by volume did not specify species or trade names; the authors therefore suggest that the country's recent cumaru export figures may be an underestimate (Norman and Rodriguez Zunino, 2021).

The seeds of ***D. alata*** (marketed as Almendra Chiquitana) were noted to be exported internationally from Bolivia (Pérez-Cruz and Villarroel, 2020), with harvest taking place in communities in the department of Santa Cruz (Delgado *et al.* 2018 in Pérez-Cruz and Villarroel, 2020). Demand for Almendra Chiquitana was reported to be growing, with Delgado *et al.* (2018 in Pérez-Cruz and Villarroel, 2020) estimating a harvest of c. nine tonnes (~9000 kg) from the Santa Cruz department for national and international use in 2018.

Brazil: The USA and the EU imported 11 million kg and around 7 million kg of cumaru timber from Brazil respectively (reported as "cumaru decking", "Brazilian teak (cumaru)", "yellow cumaru lumber", and sometimes identified as ***D. odorata***) between 2018-2021 (Panjiva, 2021a). In all cases, the species exported by Brazil is likely to be ***D. odorata***.

A study of the market for ***D. odorata*** seeds from Pará State, Brazil, reported that, in 2005, exports were mainly to Japan, France, Germany and China (da Silva *et al*., 2010). Pará was noted to produce almost all of Brazil's tonka beans at the time of the study; seeds were reported to be harvested by cattle farming families in the agricultural off-season from September to November, with each family harvesting ~80 kg of fruit equivalent to ~40 kg of dried beans (da Silva *et al*., 2010). The trade in tonka beans in the region was observed to be somewhat dependent on the Brazil nut (*Bertholletia excelsa*) trade, as middlemen only purchased tonka beans together with Brazil nuts (da Silva *et al*., 2010). Overall production in Pará for 2005 was estimated at ~108 thousand kg of beans, of which 80-90% were purchased by only two companies in Belém; however, the beans are also used in Brazil's domestic perfume and cosmetics industry (da Silva *et al*., 2010), making total export volumes unclear.

Costa Rica: According to the CITES Trade Database, exports of *D. panamensis* (***D. oleifera***) from Costa Rica 2010-2019 consisted entirely of 22.9 m^3 of artificially propagated timber exported to the USA for commercial purposes, as reported by Costa Rica.

Colombia: Colombia's National Environmental Licensing Authority (ANLA) approved the export of a total of 19 893.026 m^3 of *Dipteryx* timber between 2019 and 2020, of which 42.97% (equivalent to 8597.537 m^3) was reported as *Dipteryx* sp. and 42.72% (equivalent to 8499.17 m^3) was reported as *D. oleifera* (CITES Management Authority of Colombia *in litt.* to the European Commission, 2022). Colombia's national reporting system SUNL (Salvoconducto Unico Nacional en Linea) indicates harvest of 98 696.78 m^3 of *Dipteryx* timber between 2019 and 2021; almost 80% of this volume (78 697.52 m^3) was harvested in 2019. Of the total amount of timber harvested over this period, 75.1% (72 636.5 m^3) was reported as *Dipteryx* sp., with *D. oleifera* and *D. odorata* accounting for 23 898.86 m^3 and 1726.83 m^3 respectively (CITES Management Authority of Colombia *in litt.* to the European Commission, 2022). The majority of *Dipteryx* timber over this period was harvested in the departments of Choco (92 035.25 m^3) and Antioquia (3936.16 m^3) (CITES Management Authority of Colombia *in litt.* to the European Commission, 2022).

Guyana: The Guyana Forestry Commission (2016) reported average prices in 2015 for Tonka Bean tree (assumed to be ***D. odorata***) to be USD 162 and USD 827 per cubic metre of logs and dressed lumber, respectively. Export quantities (assumed to be measured in cubic metres of logs, no units were given) of the species over 2009-2014 were reported to be low, ranging from 112 in 2015 to 952 in 2010 (Guyana Forestry Commission, 2016).

Nicaragua: According to the CITES Trade Database, between 2010 and 2019 exports of *D. panamensis* (***D. oleifera***) as reported by Nicaragua principally comprised 254 m^3 wild-sourced sawn wood, exported for commercial purposes to Costa Rica and Cuba (Table 1). Smaller volumes of carvings, timber, and wood products were exported to Costa Rica, Cuba and the USA.

Panama: According to the CITES Trade Database, trade in *D. panamensis* (***D. oleifera***) from Panama 2010-2019 principally comprised 27 800 kg sawn wood imported for commercial purposes in 2010, as reported by Germany only. Panama also reported exports of 50 specimens to the USA for scientific purposes (Table 1).

Peru: Putzel *et al.* (2011) noted that *Dipteryx* has undergone an extractive boom in Peru over the last decade. In 2006, *Dipteryx* spp. traded under the common name shihuahuaco represented 50% of wood exports from Peru; by 2015 it was reported that this had risen to 80% (Putzel pers. comm. in Romo *et al.,* 2019). The majority of *Dipteryx* timber extracted from Peru is thought to be exported to China to provide raw material for the flooring market (Putzel *et al.,* 2011).

The principal species that are exported from Peru are unclear, in part due to the recent taxonomic changes. ***D. odorata*** had previously been considered a major timber species in Peru (Aldana Gomero *et al*., 2016) and timber has been exported from Peru under numerous *Dipteryx* spp. names including ***D. odorata***, as well as synonyms *Coumarouna odorata*, *C. micrantha*, and the trade names cumaru and shihuahuaco (Putzel *et al*., 2011). However, recent taxonomic studies indicate that ***D. odorata*** does not occur in Peru, and Studies have concluded that the timber harvested in the south of the Peruvian Amazon described as ***D. micrantha*** or ***D. odorata*** is in fact ***D. ferrea*****;** while timber extracted in the north is considered ***D. micrantha*** (Aldana Gomero *et al.,* 2016; Garcia-Davila *et al*., 2020; Honorio Coronado *et al.,* 2020; Carvalho, pers. comm. to Forest Trends, 2021). On this basis, Aldana Gomero *et al*. (2016) stated that ***D. micrantha*** is "the most commercially available species" of *Dipteryx* in Peru. Although ***D. odorata*** was included in Peru's 2016 official list of timber species (SERFOR, 2016), the species was not included in the 2020 botanical identification manual for Peruvian Amazon forest species, which only lists ***D. charapilla***, ***D. ferrea*** and ***D. micrantha*** under the genus *Dipteryx* (SERFOR, 2020).

Using data from official reports on wood extracted (MINAGRI-SERFOR forest yearbooks, anuarios forestales), 1 064 333 m^3 of Peruvian ***D. micrantha*** wood was estimated to have been harvested from 2000 to 2020, equivalent to approximately 110 079 mature trees (>51 cm DBH), although it was noted that this may be an underestimate of harvest, as the datasets used do not include ***D. micrantha*** felled for charcoal production and do not fully address illegal as well as legal logging volumes (Romo *et al. in litt*. to Forest Trends, 2022).

Analysis of trade data of Peruvian exports of timber under the common names shihuahuaco and cumaru reveals that between 2015-2018 Peru exported over 101 million kg, with roughly 79 million kg going to China, 14 million kg to the EU and 1.3 million kg to the USA (Panjiva, 2021b; SUNAT, 2021). Between 2018-2021 Peru exported over 82 million kg, with 51 million kg going to China, 19 million kg to the EU and 1.8 million kg to the USA (Panjiva, 2021b; SUNAT, 2021).

According to SERFOR, 247 395 logs of *Dipteryx* spp. were harvested as cumaru in 2019, of which 64 698 m^3 were exported as sawnwood, strips and joinery (SERFOR, 2021). For the same year, seven timber species accounted for more than 90% of the total harvested volume, all of them considered hardwood for the decking industry, of which 60% was reported as cumaru (*Dipteryx* spp.) (SERFOR, 2021).

Table 1: Trade in *Dipteryx panamensis* 2010-2019, according to the CITES Trade Database.

Exporter	Importer	Term	Unit	Source	Purpose	Reported by	Total
Costa Rica	United States of America	timber	m^3	A	T	Exporter	22.9
						Importer	
Nicaragua	Costa Rica	carvings	m^3	W	T	Exporter	18.6
						Importer	
		sawn wood	m^3	W	T	Exporter	211.3
						Importer	19.6
		timber	m^3	W	T	Exporter	49.2
						Importer	
	Cuba	sawn wood	m^3	W	T	Exporter	42.5
						Importer	
	United States of America	timber	m^3	W	T	Exporter	14.7
						Importer	
		wood product	m^3	W	T	Exporter	2.2
						Importer	2
Panama	Germany	sawn wood	kg	W	T	Exporter	
						Importer	28700
	United States of America	specimens	-	W	S	Exporter	50
						Importer	

Source: CITES Trade Database, UNEP-WCMC, Cambridge, downloaded on 11/10/2021.

Venezuela: Pérez and Souto (2011) reported that, despite a decline in demand for tonka beans since the early 20th Century, there is still a "small-scale" international market for the beans, including demand from France. The "majority" of Venezuelan tonka beans are reportedly harvested by communities in the Lower Caura River Basin region in the south of the country (Pérez and Souto, 2011), with ***D. odorata*** (Fernández pers. comm. 2010 in Pérez and Souto, 2011) thought to be the main species of harvest, although ***D. punctata*** has conversely been reported as the main Venezuelan tonka bean species (Carvalho pers. comm. to Forest Trends, 2021). Fruits are harvested from both wild and cultivated *Dipteryx* stands between February and May, with fruits of cultivated trees maturing and falling faster than those of wild trees (Pérez and Souto, 2011). Mast fruiting reportedly takes place approximately every three years, and individual trees produce an average fruit yield of 10-20 kg (Pérez and Souto, 2011). Approximately 46 kg of fruit (one collection bag) produces 2.5 kg of tonka beans, with a family processing <405 kg of tonka beans in a season (Pérez and Souto, 2011). A partnership between the local community of Aripao village and the Swiss perfume company Givaudan, supported by Conservation International and a local non-governmental organisation, Phynatura, encourages sustainable harvest of wild tonka beans in the Caura Forest Reserve, Bolivar State since 2007 (Crepin, 2016). Under the scheme, the community is compensated for monitoring and patrolling 148 000 ha of forest as well as sustainably sourcing tonka beans (Crepin, 2016).

6.3 Parts and derivatives in trade

The dense, hard, rot resistant wood of several species (***D. micrantha***, ***D. odorata***, ***D. ferrea***, ***D. oleifera*** in particular) is traded for timber under a number of common names, including cumaru shihuahuaco, charapilla, almendro and almendrillo (ITTO, 2021). It is generally used for flooring and decking (Putzel *et al.*, 2008; Putzel *et al.*, 2011).

The seeds of several species are widely used in food, flavouring, fragrance, tobacco and cosmetics industries (Bovell-Benjamin and Roberts, 2016). ***D. odorata*** and ***D. punctata*** are traded as tonka beans (Government of Venezuela, 2020) and ***D. alata*** is traded as baru nut (Kermath *et al.*, 2014), baru almond (Fernandes *et al*., 2010) or Almendra Chiquitana (Pérez-Cruz and Villarroel, 2020). The seeds are traded both whole and as processed oils and extracts. The roasted nut of ***D. alata*** is widely consumed in Brazil (Fernandes *et al*., 2010). The oil of ***D. alata*** is also used in skin care products and medicines (da Silva *et al.,* 2021).

Coumarin is a chemical compound found in high concentration in the seeds of *Dipteryx* spp. It is used as a substitute for vanilla, as well as in baked goods, tobacco and fragrance; however, there is a risk of liver toxicity if coumarin is consumed in large amounts (Bovell-Benjamin and Roberts, 2016). For this reason, tonka beans, extracts derived from the beans, or "food containing any added coumarin" are considered "adulterated" under Title 21 of the United States Code of Federal

Regulations, Volume 3, Part 189 (FDA, 2022), and coumarin is banned as a food additive in the USA (National Center for Biotechnology Information, 2021). Import of tonka beans into the USA however, remains legal. Although literature on this trade was scarce, there is some indication that tonka beans are imported whole into the USA where they are processed for use by the tobacco industry (Naveed, 2021). Under European Parliament Regulation (EC) No. 1334/2008 of 16 December 2008, coumarin is also banned as a food additive in the EU, and the natural coumarin content of certain foods (such as cinnamon) is restricted to specified maximum amounts (European Parliament, 2008).

6.4 Illegal trade

Illegal forestry activities have previously been identified within range States of the genus, including Bolivia (Norman and Rodriguez Zunino, 2021), Brazil (Santos de Lima *et al*., 2018; Amazônia Real, 2019; Forest Trends, 2021a), Colombia (Morales, 2017; EIA, 2019; Forest Trends, 2021b), Nicaragua (Richards *et al*., 2003; Government of Nicaragua, 2006a) and Peru (EIA, 2012; Global Witness, 2019; Forest Trends, 2021c). Forest Trends' 2021 Timber Legality Risk Dashboards for Brazil, Colombia and Peru consider all native forest timber species in the country, including *Dipteryx* spp*.*, to be at high risk of illegal harvest, and states that all tropical hardwood exports from Brazil and Peru should likewise be considered high risk (Forest Trends, 2021a, 2021b, 2021c).

Global Witness (2019) noted that 60% of timber inspected by Peru's Agency for the Supervision of Forest Resources and Wildlife (OSINFOR) in the Loreto and Ucayali regions between 2008 and 2018 had illegal origins, a figure deemed conservative as only 40% of concessions were inspected by the agency. It is therefore likely that the volumes of Peruvian *Dipteryx* extracted and traded are higher than those recorded in forest statistics (Romo *et al.,* 2019), or that the timber did not come from the concessions named, increasing the risk of harvest in nature reserves, protected areas or indigenous territories (Honorio Coronado, pers. comm. to Forest Trends, 2021). In addition, concerns have been raised that some imports from Peru into the EU have been in contravention of the EU Timber Regulation due diligence requirements (Ojo Publico, 2021). A 2021 analysis led by the Peruvian government investigated the laundering of illegally harvested timber into supply chains, concluding that approximately 37% of total national roundwood production in 2017 had been laundered (PCM, USAID and US Forest Service, 2021).

The two main timber-producing regions in Colombia are the Amazon and the Choco-Darien (Van Eynde *et al.,* 2015); armed groups have controlled much of the Choco region where the timber is harvested and transported in recent years (US Department of the Treasury, 2014). Between 2010 and 2020, Colombia's national seizure database (Actas Únicas de Control al Tráfico Ilegal de Fauna y Flora (AUTICS)) contained seizure records of 50 m^3 of *Dipteryx,* of which 46. 2 m^3 were *D. oleifera* wood blocks and 3.8 m^3 were boards of *Dipteryx* sp. (CITES Management Authority of Colombia *in litt.* to the European Commission, 2022).

A 2018 Forest Trends report (Schaaps and Canby, 2018) also noted that there have been recent imports of logs into China from countries that have existing log export bans, including Brazil, Bolivia, Colombia and Peru (see Section 7.1); these were considered likely to be illegally sourced, although it is not known whether any of these imports were of *Dipteryx* spp*.*

6.5 Actual or potential trade impacts

Dipteryx species are slow growing and long lived, which makes them inherently vulnerable to overharvest (see Section 3.3), and the genus is targeted for both its timber (which has the potential to impact regeneration as well as the density of adult specimens) and its seeds (potentially impacting regeneration). The market for *Dipteryx* timber and seeds is both national and international, but the international market for timber in particular has been noted to be expanding, in part as the increased scarcity and protection afforded to other Amazonian hardwoods, such as *Swietenia macrophylla* and *Cedrela odorata*, drive market diversification (Putzel *et al.*, 2011). In addition, substantial illegalities have been identified in the timber industries in some of the species' range States (Government of Nicaragua, 2006a; Schaaps and Canby, 2018; EIA, 2019; Global Witness, 2019), and regulation of trade is necessary to reduce the increasingly detrimental pressure of harvest on the species' survival in the wild. Ensuring that trade is sustainable is critical not only for the survival of the genus itself, but to maintain the important ecological role of its species as providers of food and habitat to a number of threatened species of fauna (see Section 3.5).

The populations of the four species recommended for inclusion in Appendix II in accordance with Article II, paragraph (2)(a) of the Convention and satisfying Criterion B of Annex 2a of Resolution Conf. 9.24 (Rev.CoP17) are considered to be in serious decline due to intensive harvesting for the timber trade, globally in the case of ***D. micrantha*** (Requena Suarez, 2017b) and ***D. odorata*** (Requena Suarez, 2017a), and in several range States in the case of ***D. oleifera*** (Hanson *et al*., 2006; Cardenas and Salinas, 2007). ***D. alata*** is considered in decline due to previous and ongoing timber and seed harvest (WCMC, 1998a; Requena Suarez, 2021).

Potential timber trade impacts on *Dipteryx* spp. are highlighted by Romo *et al.* (*in litt*, to Forest Trends, 2022), who used estimates of population density and area of species' range, together with data on percentage harvest (see Section 4.4), to estimate that by 2020, 33% of Peru's ***D. micrantha*** population had been extracted, and by 2036, 66% of the population could be removed. The authors' suggested classification of ***D. micrantha*** and ***D. ferrea*** as endangered and critically endangered respectively, in Peru (Romo *et al. in litt*, to Forest Trends, 2022) suggests negative impacts of trade, as Peru is thought to be one of the principal exporters of these species. Coupled with the large volumes of *Dipteryx* timber that have been exported by Brazil, Bolivia and Peru over the last decade (see Section 6.2), the need for sustainable management measures to be put in place for *Dipteryx* spp. is further emphasized. Similarly, the classification of ***D. oleifera*** as vulnerable in the Red Data Books of Colombia, Costa Rica, and Panama (see Section 4.4) highlights concerns regarding this species, which is also subject to trade pressure.

Communities in some tonka bean-producing range States cultivate *Dipteryx* spp. stands for seed harvest (Pinto *et al*., 2008), which may reduce the impact on wild populations. Additionally, a small-scale community tonka bean harvesting and forest conservation project has been running in Venezuela since 2007 (Crepin, 2016). However, harvest of ***D. alata***, ***D. odorata*** and ***D. punctata*** seeds for the tonka bean trade has the potential to impact recruitment in wild populations (Herrero-Jáuregui *et al*., 2012), particularly as *Dipteryx* spp. produce mature fruits supra-annually (Pinto *et al*., 2008), only a small percentage of mature trees may produce fruit in a given year (Herrero-Jáuregui *et al*., 2011), and there is a risk of synergistic pressure from both timber and seed harvest in some areas (Herrero-Jáuregui *et al*., 2013).

7. Legal instruments

7.1 National

Log export bans are in place in a number of range States, as outlined below. No relevant national legal instruments could be located for Bahamas, Dominica, French Guiana, Guyana, Trinidad and Tobago or Venezuela.

Bolivia: Export of logs is banned under Article 8 of Supreme Decree No. 24453 of 21 December 1996, which regulates the implementation of the Forestry Act No. 1700 of 12 July 1996 (Government of Bolivia, 1996).

Brazil: Under Normative Instruction No. 15 of 5 December 2011 (amended by Normative Instruction No. 13 of 24 April 2018 to specify that exports of charcoal of native species require authorisation from IBAMA (IBAMA, 2018)), the export of roundwood of all native species from natural forests, with the exception of *Minquartia guianensis*, is prohibited (IBAMA, 2011). No *Dipteryx* spp. were included in the country's 2014 list of endangered flora (Government of Brazil, 2014).

Colombia: According to WWF's 2015 country profile for Colombia, an export ban on roundwood from natural forests has been in place since 1997 (WWF, 2015); however, the original legislation could not be found to verify this.

Costa Rica: A ruling of Costa Rica's Constitutional Chamber banned the exploitation of ***D. oleifera*** from the wild in 2008 (including standing wood, naturally fallen wood, and residual wood), noting that the ban should remain in place until the tree species itself as well as the Great Green macaw, *Ara ambiguus* (for which ***D. oleifera*** is provides nest sites and is a critical food source) remain on the list of threatened species (Ávalos, 2008; Camacho Calvo, 2015). Camacho Calvo (2015), however, noted that a ban had not subsequently been established via legislation, such as an executive decree. Prior to this, Ministerial Decree No. 25167 of 12 June 1996 restricted the harvest of ***D. oleifera*** in the north of the country (between the San Carlos, San Juan and Sarapiquf rivers) to protect *A. ambiguus* nest trees, and a compensation payment scheme was established for owners

of isolated trees of ***D. oleifera*** and forests containing the species within the area covered by the Decree, to encourage conservation (MINAE, 1996). The export of logs and squared timber was additionally prohibited by Forest Law No. 7575 of 16 April 1996 (Government of Costa Rica, 1996); however, it is unclear whether timber from plantations is exempt from this export ban.

Ecuador: Under Article 46 of the Law on Forests and Conservation of Natural Areas and Wildlife of 10 September 2004, the export of roundwood, unless authorised by the Ministry of Environment for scientific purposes, is prohibited (Government of Ecuador, 2004).

Honduras: Export of unprocessed roundwood or squared timber of broadleaved species from natural forests is prohibited under Article 102 of Decree No. 98-2007 of 26 February 2008 (Government of Honduras, 2008).

Nicaragua: ***D. oleifera*** (under the synonym *D. panamensis*) was added to the list of species with indefinite national harvest bans by Ministerial Resolution No. 29/06 of 16 June 2006 (Government of Nicaragua, 2006a). Additionally, the export of roundwood, timber and sawn timber of "any forest species" from natural forests was prohibited by Law No. 585 of 21 June 2006 (Government of Nicaragua, 2006b).

Panama: Under Decree No. 107 of 19 January 2021, export of logs from natural forests or reservoirs that have not undergone primary processing or treatment (against insects and fungi) is prohibited; exported timber must also originate from areas with sustainable forest management plans endorsed by the Ministry of Environment (Government of Panama, 2021). Previously, export of unprocessed timber from natural forests was restricted by Decree No. 83 of 6 August 2008 (Government of Panama, 2008), but this was repealed in January 2016 by Decree No. 7 as the restrictions were considered to have been "ineffective" at stimulating wood processing mechanisms within the national timber industry (Government of Panama, 2016b).

Paraguay: Under Decree No. 24498/72 of 18 February 1972, the export of roundwood, logs and beams is prohibited (Government of Paraguay, 1972).

Peru: According to TRAFFIC's 2014 briefing document on Peru, a ban on the export of logs from natural forests has been in place since 1972 (TRAFFIC, 2014). However, the original legislation could not be found to verify this.

Suriname: Under the Forest Management Law of 18 September 1992, ***D. odorata*** and ***D. punctata*** are listed as Category C species, making felling these species illegal unless specifically approved by the Forestry Department (Government of Suriname, 1992). Additionally, a permit is required for the export of "raw wood, round wood, round or felled pole wood, processed wood, wood products and forest by-products" (Customs Suriname, 2003).

7.2 International

D. oleifera was listed in CITES Appendix III by Costa Rica in 2003 and Nicaragua in 2007, under its synonym *D. panamensis*, due to concerns about overexploitation for the timber trade. *D. panamensis* from Costa Rica and Nicaragua was also listed in Annex C of the EU Wildlife Trade Regulations in 2003 and 2008 respectively.

Both Guyana and Honduras have agreed FLEGT Voluntary Partnership Agreements (VPAs) with the EU to ensure that timber and timber products exported to the EU are legally-sourced (European Forest Institute, 2020). The EU-Honduras VPA was signed in February 2021, and the EU-Guyana VPA has yet to be signed (European Forest Institute, 2020).

8. Species management

8.1 Management measures

No information on genus or species-specific management plans was found for *Dipteryx* spp. However, minimum exploitable diameters (MEDs) have been established in a number of range States, as below.

Brazil: The current MED for species of *Dipteryx* is 50 cm (Vinson *et al*., 2015). However, a modelling study of the ***D. odorata*** population in Brazil suggested that the MED should be increased to 100 cm, with cutting cycles of 30 years, in order to achieve sustainable timber harvest (Vinson *et al*., 2015).

Guyana: Under the Forest Regulations of 1 January 1953, the MED for all tree species unless otherwise specified is 60.96 cm (24 inches) (Government of Guyana, 1953).

Panama: Resolution No. 5 of 22 January 1998 specifies that logging permit holders must record volumes felled and pay the costs of surveys, inspections and technical services for all trees ≥20 cm in diameter (Government of Panama, 1998). This may imply an MED of 20cm for all species.

Peru: According to the World Resources Institute's 2014 Peru country profile, forest concession agreements require reduced impact logging practices, cutting rotations of at least 20 years, and the retention of a minimum of 10% of mature adult trees (seed trees) of each harvested species to enable regeneration (WRI, 2014). Karsten *et al*. (2014) reported that a 1805 km^2 forest concession in Alto Ucayali, east-central Peru, which included ***D. micrantha***, was managed using a 30 year cutting cycle and an average applied logging intensity of 12 m^3 per ha per year.

Suriname: ***D. odorata*** and ***D. punctata*** are protected under the Forest Management Law of 18 September 1992 (Government of Suriname, 1992). All other marketable or potentially marketable tree species have MEDs of 35 cm (Government of Suriname, 1992).

Venezuela: Reportedly, forest concession holders may only extract trees greater than 40 cm DBH (not specific to *Dipteryx* spp.) (Global Forest Watch, 2002).

8.2 Population monitoring

Dipteryx species are monitored in Peru by the Amazon Forest Inventory Network collaboration, known as RAINFOR, using 356 permanent plots covering a total of 165 hectares of primary forest in the Peruvian Amazon (Honorio Coronado *et al.,* 2018).

8.3 Control measures

8.3.1 International

See Section 7.2.

8.3.2 Domestic

See Section 8.1.

8.4 Captive breeding and artificial propagation

D. oleifera timber plantations have been established in Panama and Costa Rica, with greatest growth success reported in Atlantic lowland regions of Costa Rica with high rainfall and well-drained soils (Schmidt, 2009). In Costa Rica, an experimental plot planted with 49 ***D. oleifera*** individuals in 1985 was reported to have a 14% survival rate after 24 years, although the surviving trees were "straight and of good form" (Schmidt, 2009). Brightsmith (2005) additionally reported that planting schemes for *Dipteryx* spp. in Costa Rica have successfully produced fruiting trees. In pure stands of ***D. oleifera*** within a plantation at La Selva Biological Station, Costa Rica, Montagnini *et al*. (2003) estimated rotation periods of 25 and 32 years for thinned and unthinned stands, respectively. *Dipteryx* spp. plantations have also been established in Trinidad and Tobago, and possibly also Jamaica, for seed collection and as shade trees for cocoa. Plantations have also reportedly been established in the Experimental Annex von Humbolt in Ucayali, in Peru (Flores, 2014 in Romo *et al*., 2019; Honorio Coronado, pers. comm. 2021). *Dipteryx* spp. (***D. odorata*** or ***D. punctata***) are cultivated by local communities in southern Venezuela to supplement tonka bean harvest from wild stands and for conservation of the species (Pérez and Souto, 2011).

8.5 Habitat conservation

In Peru, ***D. micrantha*** is found in the following protected areas: Bahuaja Sonene National Park, Manu National Park, Alto Purús National Park and El Sira Communal Reserve (Romo *et al*., 2019). Distribution modelling for ***D. alata*** in Brazil predicted the species' occurrence within several protected

areas in the Araguaia Valley and the Rio das Mortes Wetlands (CNCFlora, 2012), and the species was also noted to be conserved by some local communities in Goiás State, Brazil, whose livelihoods are based on ***D. alata*** almond (seed) production (Nabout *et al*., 2010). A conservation assessment of ***D. oleifera*** in Costa Rica found that only 3.8% of the species' habitat in the range State was within a government protected area (Estrada Chavarría *et al*., 2005 in Fliesswasser, 2014). ***D. polyphylla*** is reported to occur in Jamari National Forest protected area, Brazil (Hills, 2021).

8.6 Safeguards

See Section 7.1

9. Information on similar species

According to the Thünen Institute of Wood Research in Germany, it is not possible to clearly distinguish the individual species within the genus *Dipteryx* using macroscopic and microscopic identification of wood anatomy (Koch, pers. comm. to Forest Trends, 2021). However, identification of ***D. alata***, ***D. ferrea***, ***D. micrantha***, ***D. odorata*** and ***D. punctata*** using genetic markers is currently possible (Honorio Coronado *et al.,* 2020). Samples of *Dipteryx* spp. are soon to be included in the database of species identifiable in the field using the open source, field deployable XyloTron platform (Ravindran *et al.,* 2021). Several species of *Dipteryx* are traded under the common names cumaru or shihuahuaco and are neither distinguishable nor identified to species level in trade (Aldana Gomero *et al*., 2016). For example, ***D. punctata*** is less known in international markets but is generally misidentified as ***D. odorata*** (de Lima and Carvalho, pers. comm). According to Koch (*in litt*. to IUCN and TRAFFIC, 2019), ***D. alata*** and ***D. odorata*** are "commonly confused" with *Handroanthus* spp., *Tabebuia* spp. and *Roseodendron* spp. (collectively known as "ipê") in trade, although it is possible to differentiate between *Dipteryx* and ipê timber based on microscopic wood characteristics.

10. Consultations

A consultation was distributed by the European Union to all range States in December 2021.

11. Additional remarks

Following publication of the latest taxonomy on the genus *Dipteryx* in 2022 there will be further clarity regarding nomenclature and species distributions (Carvalho pers. comm. to Forest Trends, 2021). Given the inconsistency of both common and scientific names used in trade and the difficulty in identifying to species level, a genus listing according to Criterion A in Annex 2b of Res. Conf. 9.24 (Rev. CoP17) should be considered going forward.

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