

# Plant species indicated for the recovery of degraded areas in Rondônia, Brazil

Késid Rafael Cavalcante PAIXÃO<sup>1\*</sup>, Marcela CAMPANHARO<sup>2</sup>, Antônio Laffayette Pires da SILVEIRA<sup>1,3</sup>

<sup>1</sup> Universidade Federal de Rondônia - UNIR, Programa de Pós-Graduação em Conservação e Uso dos Recursos Naturais – PPGReN, Porto Velho, RO, Brazil

<sup>2</sup> Universidade Federal do Espírito Santo - UFES, Departamento de Ciências Agrárias e Biológicas, São Mateus, ES, Brazil

<sup>3</sup> Universidade Federal de Rondônia - UNIR, Departamento de Biologia, Porto Velho, RO, Brazil

\*Corresponding author: kesidpaixao@gmail.com

## ABSTRACT

Secondary forests account for more than half of the planet's tropical formations. It is necessary to understand these forests in order to allow for efficient recovery and restoration processes of altered areas. In Rondônia state, in the Brazilian Amazon, where much of the natural vegetation cover has been altered over the last several decades, secondary forests have become particularly important. In this study, we selected species for restoration in Rondônia based on published work on secondary forests in the state, complemented with field collections by the authors. For each of the selected species, the successional category, dispersal syndrome and functional group was searched in the literature. Information regarding flowering and fruiting times as well as geographic distribution and habitats occupied in the state were obtained from vouchers deposited in herbaria. We listed 55 species from 49 genera and 23 families, of which 40% can be characterized as pioneers, 52.7% as secondary and 5.4% as climax species. Regarding functional group, 49% are diversity species and 34.5% are cover species. As for the dispersal syndrome, 60% are zoochoric, 16.3% anemochoric and 10.9% barochoric. Almost all of the species included in the list are common throughout the state and most are easy to recognize and identify. The species listed are present in all the main environments of Rondônia, and most are from *terra firme* forest. The listed species have the potential to play a fundamental role in the establishment and development of forests in altered and/or degraded areas in the state.

**KEYWORDS:** Amazon, deforestation, secondary forest, restoration

## Espécies de plantas indicadas para recuperação de áreas degradadas em Rondônia, Brasil

### RESUMO

As florestas secundárias representam mais da metade das formações tropicais do planeta. Compreender essas florestas é necessário para permitir processos eficientes de recuperação e restauração de áreas alteradas. No estado de Rondônia, na Amazônia brasileira, onde grande parte da cobertura vegetal natural foi alterada nas últimas décadas, as florestas secundárias tornaram-se particularmente importantes. Neste estudo, selecionamos espécies para restauração em Rondônia com base em trabalhos publicados sobre florestas secundárias no estado, complementados com estudos de campo realizados pelos autores. Para cada uma das espécies selecionadas, a categoria sucessional, a síndrome de dispersão e o grupo funcional foram pesquisados na literatura. Informações sobre o período de floração e frutificação, bem como a distribuição geográfica e os habitats ocupados no estado, foram obtidas de comprovantes depositados em herbários. Listamos 55 espécies de 49 gêneros e 23 famílias, das quais 40% podem ser caracterizadas como pioneiras, 52,7% como secundárias e 5,4% como espécies clímax. Em relação ao grupo funcional, 49% são espécies de diversidade e 34,5% são espécies de cobertura. Quanto à síndrome de dispersão, 60% são zoocóricas, 16,3% anemocóricas e 10,9% barocóricas. Quase todas as espécies incluídas na lista são comuns em todo o estado e a maioria é fácil de reconhecer e identificar. As espécies listadas estão presentes em todos os principais ambientes de Rondônia e a maioria é de floresta de terra firme. As espécies listadas têm o potencial de desempenhar papel fundamental no estabelecimento e desenvolvimento de florestas em áreas alteradas e/ou degradadas no estado.

**PALAVRAS-CHAVE:** Amazônia, desmatamento, floresta secundária, restauração

**CITE AS:** Paixão, K.R.C.; Campanharo, M.; Silveira, A.L.P. 2026. Plant species indicated for the recovery of degraded areas in Rondônia, Brazil. *Acta Amazonica* 56: e56ag24163

## INTRODUCTION

In the Brazilian Amazon, deforestation rates have proven resistant to change, year after year, increasing the percentage of deforested areas, notably in the “Deforestation Arch” along the eastern to southwestern rim of the Brazilian Amazon, where the state of Rondônia is located (PRODES 2021; Terrabrasilis 2023). From 1988 to 2024, the Brazilian Amazon lost approximately 500,000 km<sup>2</sup> of forests, of which more than 67,000 km<sup>2</sup> were in Rondônia (PRODES 2024), that has gone through several economic cycles based on rubber, minerals and currently on agribusiness, all of which have fomented large-scale environmental degradation (Fearnside 1989; Piontekowski *et al.* 2014).

Large-scale changes in natural vegetation cover, through clearing and burning, bring harmful consequences to the environment such as loss of local biodiversity, silting of rivers and changes in the hydrological cycle (Fearnside 2005, 2006; Correia *et al.* 2007; Watanabe *et al.* 2018; Souza *et al.* 2019). Another effect is the intense release of greenhouse gases, such as carbon dioxide, methane and nitrous oxide, which in turn, although they are measured regionally, have their effects extended on a global scale due to their contribution to global warming (Fearnside 2006).

The forest restoration/recovery actions can be efficient strategies for reversing forest loss and degradation through the conservation of local biodiversity and environmental services and in mitigating climate change (Joly 2007; Albuquerque and Silva 2008; Santos 2014; Benini *et al.* 2016). Accordingly, the UN General Assembly proclaimed the period 2021-2030 as the Decade of Ecosystem Restoration aiming to “support and expand efforts to prevent, deter and reverse the degradation of ecosystems” (UN 2019). This initiative highlights the importance and urgency of actions aimed at restoring and recovering degraded areas. At the UN conference, Brazil established goals to restore degraded areas in Brazilian biomes, committing to restore a total of 12 million hectares (Lima *et al.* 2022).

The Amazonian flora is characterized by a high species richness, with a confirmed occurrence of more than 14,000 plant species (Cardoso *et al.* 2017). In this scenario, difficulties arise for the various actors, seed collectors, reforesters, NGOs, that interact in the process of ecological recovery and restoration of degraded areas. Selecting the most suitable forest species for these purposes is one of the greatest demands of the sectors involved in recovery/restoration processes in the Amazon. In this sense, reliably identifying and working *in situ* with species suitable for the recovery and restoration of degraded/alterated areas should be the first step to be achieved in the face of the challenges of these processes, allowing for greater diversity in the safe choice of species and probability of recovery (Barbosa *et al.* 2017).

In Rondônia, degraded areas occupy an increasing proportion of the landscape among the phytophysionomies in the state (IBGE 2021). Therefore, our objective in this study was to determine tree and palms species known to occur in Rondônia and that have attributes suitable for restoration and recovery programs.

## MATERIAL AND METHODS

### Species selection

The composition of the list of tree and palm species indicated for restoration and recovery of degraded areas was based firstly on the species being reported in works published about secondary forests and degraded areas for the state of Rondônia, Brazil (Lisboa 1989; Isernhagen 2015; Benini *et al.* 2016; Paixão and Silveira 2020; Scoti *et al.* 2020; Vieira *et al.* 2021). The list was complemented by field observations carried out by the authors since 2016 in monitoring work on recovered areas in northern Rondônia.

To select the best species for the list, the following criteria were considered: (a) species with abundance greater than 5%; (b) species with natural distribution in Rondônia based on herbarium data; (c) taxa consistently determined at the species level; and (d) availability of relevant ecological information on the species regarding successional category, functional group and dispersal syndrome. The organization of families was based on the APG IV system (Chase *et al.* 2016) and the species names were updated based on Flora e Funga do Brasil (2023).

### Ecological data

Information regarding successional categories, dispersal syndrome and functional group was obtained by consulting published works (Beltrame and Rodrigues 2007; Andrade *et al.* 2011; Condé and Tonini, 2013; Klippel *et al.* 2015; Ribeiro 2016; Barbosa 2017; Paixão and Silveira 2020; Barbosa *et al.* 2021). We determined “successional category” based on seed production, tolerance/intolerance to light and growth time, classifying species into pioneers, secondary and climax species. The characterization of each group can be found in Rodrigues *et al.* (2009).

Dispersal syndromes result from morphological, chemical and biological characteristics of the propagules that favor the action of specific dispersing agents (Vieira *et al.* 2002), based on which the species were classified as anemochoric, hydrochoric, autochoric, barochoric and zoochoric. The characterization of each of the syndromes can be found in Rodrigues *et al.* (2009).

Functional groups (Barbosa 2017), also defined as planting groups (Rodrigues *et al.* 2009), refer to the system of classifying plants according to their different growth patterns and canopy density. Under this system, plants are divided into two groups: filling or covering species and diversity species. Filling species are fast-growing species with dense canopies, which allow for rapid soil coverage. Diversity species, on the other hand, lack these characteristics but

contribute to the species richness of the restored area. The characterization of each group can be found in Rodrigues et al. (2009) and Barbosa et al. (2017).

Data on reproductive phenology and distribution of species in the state of Rondônia were taken from botanical records on online platforms: JABOT from the Herbarium Rondoniense (<http://ron.jbrj.gov.br/v2/login.php>), the database of the Emilio Goeldi Paraense Museum (<https://floradobrasil.jbrj.gov.br/>), the New York Botanical Garden (<https://sweetgum.nybg.org/science/ih/>), and Specieslink (<https://specieslink.net/>).

A table was created showing the habitats in which each species occurs, based on information from Flora e Funga do Brasil (2023). Based on collection records in Rondônia on the Specieslink platform (Specieslink 2023), we created a distribution map in the state for the 15 species with the highest number of records.

## RESULTS

We selected 55 tree and palm species with potential for use in restoration and recovery of degraded areas (Table 1). The species belong to 49 genera and 23 families. The family with the largest number of species on the list is Fabaceae with 17 species, corresponding to 30.9% of the total. Of the remaining families, 14 had only one species (25.4%) and six families had two to five species (43.7%).

Regarding ecological groups, 22 of the species are pioneers (40%), 29 are typical of secondary forests (52.7%) and three are

typical climax species (5.4%) (Supplementary Material, Table S1). No information was found about the ecological group of *Godmania aesculifolia* (Kunth) Standl. Regarding functional groups, 27 species belonged to the diversity group (49%) and 19 species belonged to the covering group (34.5%). We found no information regarding functional characteristics for eight species (14.5%). Regarding dispersal syndrome, 33 (60%) of the species are zoochoric, nine (16.3%) are anemochoric, six (10.9%) are barochoric and three (5.4%) are autochoric.

There were two main groups regarding flowering and fruiting periods. One group includes species in that flowering and fruiting occurs throughout the dry season, between June and August. In the second group, flowering and fruiting occurs in the transition period between the dry and rainy seasons, from September to November. For 11 species we only found information on the flowering period, and for 15 only on the fruiting period.

The 15 selected species occur in one or more of the main physiognomies that exist in Rondônia (Figure 1), including open environments such as *campinarana* and *cerrado*, seasonal semideciduous forests and floodplain forests by whitewater rivers (*várzea*) and blackwater rivers (*igapós*). *Terra firme* forest was the physiognomy with the largest number of species, with 46 (83.6%), followed by semideciduous forests (30 and 54%), floodplain forests (29 and 52.7%), and different physiognomies of *cerrado* (13 and 23.6%) (Table 1). *Caryocar brasiliense* Cambess. was the only species to occur only in *cerrado*. The vast majority of species occurred in more than one physiognomy.

**Table 1.** Tree and palm species recommended for use in restoration and recovery of degraded areas in the state of Rondônia (Brazil) and their respective ecological attribute, phenology, and habitats with natural occurrences. SC = successional category (P = pioneer, S = secondary, C = climax); PG = planting group (R = covering, D = diversity); DS = dispersal syndrome (Zoo = zoochoric, Ane = anemochoric, Bar = barochoric, Aut = autochoric); ID = insufficient data. Asterisks (\*) indicate species threatened with extinction according to the Ministry of the Environment ordinance 443 of December 17, 2014). Two asterisks (\*\*) indicate habitat based on the authors field experience.

Family	Species	Local popular name	SC	PG	DS	Flowering	Fruiting	Habitat
Anacardiaceae	<i>Anacardium spruceanum</i> Benth. ex Engl.	Cajuí	S	-	Zoo	Apr-Jun	Jun-Aug	Floodplain forest ( <i>igapó</i> ), <i>terra firme</i> forest
	<i>Tapirira guianensis</i> Aubl.	Pau-pombo	P	R	Zoo	Jul-Aug	Oct-Dec	Anthorized areas, <i>cerrado</i> ( <i>lato sensu</i> ), <i>terra firme</i> forest, semideciduous forest
Annonaceae	<i>Annona ambotay</i> Aubl.	Envira	P	-	Zoo	Jun	ID	Floodplain forest ( <i>igapó</i> ), <i>terra firme</i> forest
Araliaceae	<i>Didymopanax morototoni</i> (Aubl.) Decne. & Planch.	Morototó	P	D	Zoo	ID	Aug-Oct	<i>Cerrado</i> ( <i>lato sensu</i> ), <i>terra firme</i> forest, semideciduous forest
Arecaceae	<i>Euterpe precatoria</i> Mart.	Açaí-solteiro	S	D	Zoo	ID	ID	<i>Terra firme</i> forest, floodplain forest ( <i>várzea</i> )
Bignoniaceae	<i>Godmania aesculifolia</i> (Kunth) Standl.	Ipê-verde	-	D	Ane	ID	Apr-Jun	Anthorized areas*, <i>terra firme</i> forest*, semi-deciduous forest, Amazonian savanna
	<i>Handroanthus serratifolius</i> (Vahl) S. Grose	Ipê-amarelo	S	D	Ane	Jun-Aug	ID	<i>Terra firme</i> forest
Bixaceae	<i>Bixa arborea</i> Huber	Urucum-de-índio	P	R	-	Jan-Apr	Jun-Aug	Anthorized areas, <i>terra firme</i> forest
	<i>Bixa orellana</i> L.	Urucum-de-índio	P	R	Zoo	Apr-May	May-Jun	Anthorized areas, <i>cerrado</i> ( <i>lato sensu</i> ), <i>terra firme</i> forest, floodplain forest ( <i>várzea</i> ), semideciduous forest
Boraginaceae	<i>Cordia goeldiana</i> Huber	Freijó	S	D	Zoo	Aug	Oct	<i>Terra firme</i> Forest
Cannabaceae	<i>Trema micranthum</i> (L.) Flor	Periquiteira	P	R	Zoo	Jan-Nov	Nov-Jan	Anthorized areas**, <i>terra firme</i> forest**, semideciduous forest

Table 1. Continued.

Family	Species	Local popular name	SC	PG	DS	Flowering	Fruiting	Habitat
Caryocaraceae	<i>Caryocar glabrum</i> (Aubl.) Pers.	Pequiarana	S	R	Zoo	Aug-Oct	ID	<i>Terra firme</i> forest
	<i>Caryocar brasiliense</i> Cambess.	Pequiá	S	D	Zoo	Sep-Oct	Nov-Feb	Cerrado ( <i>lato sensu</i> )
Euphorbiaceae	<i>Alchornea discolor</i> Poepp.	Supiarana	S	D	Zoo	Oct	Nov	Amazonian <i>campinarana</i> , grassland, <i>cerrado</i> ( <i>lato sensu</i> ), floodplain forest ( <i>igapó</i> and <i>várzea</i> ), <i>terra firme</i> forest, Amazonian savanna
	<i>Aparisthmium chordatum</i> (A.Juss.) Baill.	Pau-feicho	P	D	Aut	Oct-Nov	Dec-Feb	<i>Terra firme</i> forest
	<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll.Arg.	Seringueira	S	R	Bar	Jul-Sep	Nov-Feb	Floodplain forest ( <i>várzea</i> ), <i>terra firme</i> forest**
	<i>Mabea speciosa</i> Müll. Arg.	Taquari	P	D	Bar	ID	Mar	Amazonian <i>campinarana</i> , floodplain forest ( <i>igapó</i> and <i>várzea</i> ), <i>terra firme</i> forest
	<i>Maprounea guianensis</i> Aubl.	Cascudinho	S	D	Zoo	ID	Dec	<i>Cerrado</i> ( <i>lato sensu</i> ), <i>terra firme</i> forest, seasonally deciduous forest
Fabaceae	<i>Bauhinia acreana</i> Harms	Pata-de-vaca	P	D	Ane	Jan-Mar	Mar-May	Anthorized areas, <i>terra firme</i> forest
	<i>Cassia grandis</i> Lf.	Mari-mari	P	R	Aut	Sep-Oct	ID	<i>Terra firme</i> forest, semideciduous forest
	<i>Copaifera langsdorffii</i> Desf.	Copaíba	S	D	Zoo	ID	ID	Anthorized areas, <i>cerrado</i> ( <i>lato sensu</i> ), <i>terra firme</i> forest, semideciduous forest
	<i>Dialium guianense</i> (Aubl.) Sandwith	Pororoca	S	D	Zoo	Oct-Nov	Mar-Jun	Anthorized areas, floodplain forest ( <i>igapó</i> and <i>várzea</i> ), <i>terra firme</i> forest, semideciduous forest
	<i>Dinizia excelsa</i> Ducke	Faveira-ferro	C	-	Bar	Apr.	Aug-Oct	<i>Terra firme</i> forest
	<i>Enterolobium maximum</i> Ducke	Orelha-de-macaco	S	R	-	Jul	ID	<i>Terra firme</i> forest
	<i>Hymenaea courbaril</i> L.	Jatobá	S	D	Zoo	Apr-Jul	ID	Anthorized areas, <i>cerrado</i> ( <i>lato sensu</i> ), <i>terra firme</i> forest
	<i>Inga alba</i> (Sw.) Willd.	Ingá	S	R	Zoo	Jul-Aug	Aug-Jan	Floodplain forest ( <i>igapó</i> and <i>várzea</i> ), <i>terra firme</i> forest
	<i>Inga edulis</i> Mart.	Ingá-de-metro	S	R	Zoo	May-Jul	Nov-Dec	Anthorized areas, semideciduous forest
	<i>Inga marginata</i> Willd.	Ingá	S	R	Zoo	June	ID	Anthorized areas, grassland, <i>terra firme</i> forest, Floodplain forest ( <i>várzea</i> ), semideciduous forest
	<i>Inga umbratica</i> Poepp. & Endl.	Ingá-pequeno	P	R	Zoo	ID	ID	Anthorized areas, <i>terra firme</i> forest
	<i>Jacaranda copaia</i> (Aubl.) D. Don	Pará-pará	P	D	Ane	Jun-Aug	ID	<i>Terra firme</i> forest
	<i>Naiadendron duckeanum</i> (Occhioni) AG Lima, Paula-Souza & Scalon	Fava-branca	P	R	Aut	Mar-May	Jun-Aug	Anthorized areas**, <i>terra firme</i> forest
	<i>Peltogyne paniculata</i> Benth.	Roxinho	S	-	-	Jan-Jun	Apr-Aug	Floodplain forest ( <i>igapó</i> ), <i>terra firme</i> forest, Amazonian savanna
	<i>Schizolobium parahyba</i> (Vell.) Blake	Paricá	P	D	Ane	Jun-Aug	Aug	Anthorized areas, <i>terra firme</i> forest, semideciduous forest
	<i>Stryphnodendron pulcherrimum</i> (Willd.) Hochr.	Baginha	P	D	Zoo	Sep-Oct	May-Aug	Anthorized areas**, floodplain forest ( <i>igapó</i> ), <i>terra firme</i> forest, Amazonian savanna
<i>Tachigali guianensis</i> (Benth.) Zuccchi & Herend.	Taxi-vermelho	P	-	Ane	Jun-Aug	Jan-May	Anthorized areas**, floodplain forest ( <i>igapó</i> and <i>várzea</i> ), <i>terra firme</i> forest, semideciduous forest	
Goupiaceae	<i>Goupia glabra</i> Aubl.	Cupiúba	S	D	Zoo	Mar	ID	<i>Terra firme</i> forest, floodplain forest ( <i>várzea</i> )
Lauraceae	* <i>Mezilaurus itauba</i> (Meisn.) Taub. Ex Mez	Itaúba	S	D	Zoo	Mar	Jun-Jul	<i>Terra firme</i> forest, floodplain forest ( <i>várzea</i> )
Lecythidaceae	* <i>Bertholletia excelsa</i> Bonpl.	Castanheira	S	D	Bar	Nov	Jun-Aug	Anthorized areas, <i>terra firme</i> forest
	<i>Couratari stellata</i> ACSm.	Tauari	C	-	Ane	ID	ID	<i>Terra firme</i> forest
	<i>Eschweilera coriacea</i> (DC.) S. A. Mori	Matá-matá	S	D	Bar	Aug-Oct	Oct-Dec	<i>Terra firme</i> forest

Table 1. Continued.

Family	Species	Local popular name	SC	PG	DS	Flowering	Fruiting	Habitat
	<i>Apeiba echinata</i> Gaertn.	Pente-de-macaco	P	R	Zoo	Oct	Jul	Anthorized areas, terra firme forest, floodplain forest (várzea)
	<i>Apeiba tiburou</i> Aubl.	Pente-de-macaco	P	D	Zoo	Oct-Nov	Jul-Aug	Anthorized areas, cerrado (lato sensu), terra firme forest
Malvaceae	<i>Guazuma ulmifolia</i> Lam.	Mutamba	P	R	Zoo	Mar	May-Jul	Anthorized areas, cerrado (lato sensu), terra firme forest, semideciduous forest
	<i>Ochroma pyramidale</i> (Cav. ex Lam.) Urb.	Pau-de-balsa	P	R	Ane	ID	ID	Anthorized areas, terra firme forest**
	<i>Theobroma grandiflorum</i> (Willd. ex Spreng.) K.Schum.	Cupuaçú	S	D	Zoo	Jul-Oct	Nov-Jan	Anthorized areas, terra firme forest
Melastomataceae	<i>Bellucia grossularioides</i> (L.) Triana	Goiaba-de-anta	S	R	Zoo	Mar-Apr	May	Anthorized areas, terra firme forest
	<i>Miconia dispar</i> Benth.	Tinteiro	S	-	Zoo	ID	Jul-Aug	Terra firme forest
	<i>Miconia poeppigii</i> Triana	Buxixu	S	-	-	Jun-Aug	Jul-Oct	Terra firme forest
Meliaceae	* <i>Cedrela odorata</i> L.	Cedro	C	D	Ane	Jul	Jun	Cerrado (lato sensu), floodplain forest (várzea), seasonally deciduous forest
Muntingiaceae	<i>Muntingia calabura</i> L.	Pau-seda	P	R	Zoo	May-Sep	May-Sep	Anthorized areas, terra firme forest
Rubiaceae	<i>Genipa americana</i> L.	Genipapo	S	D	Zoo	ID	ID	Anthorized areas, cerrado (lato sensu), floodplain forest (igapó and várzea), terra firme forest, seasonally deciduous forest
Sapotaceae	<i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.	Abiu	S	D	Zoo	Jul-Sep	Oct	Anthorized areas, semideciduous forest
Simaroubaceae	<i>Simarouba amara</i> Aubl.	Caixeta	S	R	Zoo	Jul-Aug	Sep-Dec	Cerrado (lato sensu), terra firme forest, semideciduous forest
Urticaceae	<i>Pourouma guianensis</i> Aubl.	Embaubarana	P	-	Zoo	ID	ID	Terra firme forest, floodplain forest (várzea)
Vochysiaceae	<i>Qualea paraensis</i> Ducke	Mandioqueira	S	D	Bar	Aug	Oct	Terra firme forest

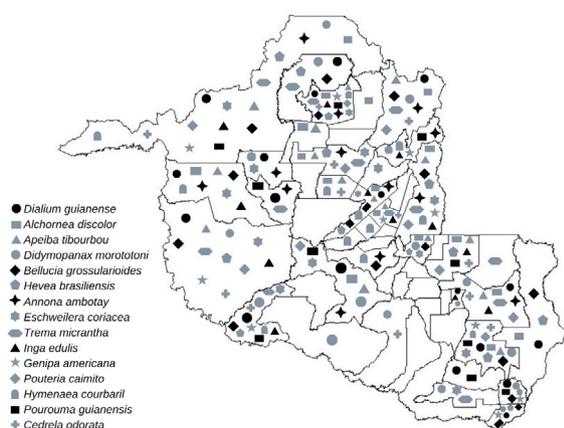


Figure 1. Distribution of 15 tree species recommended for recovery/restoration of degraded areas in Rondônia state (Brazil) with the highest number of proven records in the surveyed herbaria.

### Distribution of species in the state

More than 450 herbarium specimens were analyzed for the 55 species indicated for restoration and recovery of degraded areas. *Dialium guianense* Aubl. was the species with the highest number of locations with proven occurrence (18 municipalities), followed by *Alchornea discolor* Poepp. (17). Half of the species (30) occurred in more than eight municipalities. In contrast, *Ochroma pyramidale* (Cav. ex

Lam.) Urb. and *Cassia grandis* L.f. were recorded only in the municipality of Porto Velho.

We found occurrence records of listed species for 45 of the 52 municipalities in Rondônia, showing the need for a more thorough sampling of the Rondônia flora. The municipalities that presented the highest number of species with proven occurrence were Porto Velho with 53 registered species, Itapuá do Oeste (38) and Guajará-mirim (27). Four municipalities presented one record (Alto Alegre dos Parecis, Brasilândia d'Oeste, Cujubim and Mirante da Serra).

### DISCUSSION

We were able to recommend 55 tree and palm species native to the state of Rondônia for environmental restoration and recovery. They were recorded in fieldwork carried out by the authors or were indicated in published references that examined the flora of the state of Rondônia (Lisboa 1989; França 1991; Sanquetta *et al.* 2017; Vieira *et al.* 2021). The selected species are widely distributed in Amazonian forest formations (ter Steege *et al.* 2013), and 16 species are part of the list of 227 hyperdominant species proposed for the Amazon flora (ter Steege *et al.* 2016).

The family with the largest number of recommended species is Fabaceae, which is one of the most important in

the Amazon flora (ter Steege *et al.* 2013; Cardoso *et al.* 2017; Santos *et al.* 2018; Paixão and Silveira 2020), and in tropical forests in general (ter Steege *et al.* 2013). Fabaceae plays an important role in the recovery of degraded areas (Sprent and Platzmann 2001), as many of its species fix nitrogen (Siddique *et al.* 2008), and play a role in soil restoration and the formation of organic matter (Resh *et al.* 2002; Nardoto *et al.* 2008), which enables the re-colonization of vegetation and an increase in biodiversity (Siddique *et al.* 2008).

The Arc of Deforestation, which extends from the eastern to the southwestern rim of the Brazilian Amazon, is subject to intense deforestation and burning. Some tree species, although widely distributed, are restricted to the Arc of Deforestation (Lisboa 1989; Silveira and Paixão 2019). They may therefore, to some extent, fit into one of the extinction risk categories for the Arc of Deforestation region, such as *Swietenia macrophylla* King, *Amburana acreana* (Ducke) A.C.Sm. and *Godmania aesculifolia* (Lisboa 1989; Silveira and Paixão 2019). Developing actions that seek to conserve these species are necessary in the northern region of Rondônia, where *G. aesculifolia* is among the species used in the recovery of degraded areas (personal observation by the authors).

*Astrocaryum tucuma* Mart. (*tucumã*), *Vismia brasiliensis* Choisy and *V. guianensis* (Aubl.) Choisy (*lacre*), *Cecropia* sp. (*embaúba*) and *Solanum* sp. (*jurubeba*) were not selected in this study because they naturally show better results in degraded areas than the planted species, being generalist species that quickly colonize the environment (Monaco *et al.* 2003; Mesquita *et al.* 2001). In this way, excessive settlement by these species occurs in degraded areas (personal observation by the authors) and can become a barrier to the development of other species, thus negatively affecting regenerating plant diversity. Therefore, planting these species is neither necessary nor recommended. The use of these species needs to be defined carefully and studied further.

The low number of collections in Rondônia for most species makes it impossible to understand their real distribution. Although they are common and easily identified species, they are rarely collected and recorded in the state, which does not reflect the high dominance and abundance observed in the field. This is, for example, the case of species such as *Cassia grandis*, *Couratari stellata* A.C.Sm., *Cordia goeldiana* Huber, *Theobroma grandiflorum* (Willd. ex Spreng.) K.Schum., *Guazuma ulmifolia* Lam. and *Peltogyne paniculata* Benth., among others. In our many field activities, we observed that these species are widely distributed throughout Rondônia. Even though they are easily found in a fertile state and are widely dispersed, when searching for information to compose the database that originated the present work, few records were found for Rondônia, which makes more detailed study impossible regarding its distribution in the state. Therefore, studies focused on secondary physiognomies are necessary to close knowledge gaps.

A greater proportion of flowering or fruiting species was observed in the dry period (June through August) and in the transition period from dry to rainy (September through November). Likewise, in the Tapajós region of Pará, a greater number of flowering species was observed in the dry season and transition to the rainy season (August through February) (Leão *et al.* 2001). The latter authors observed, over 14 years, much variation in periods of flowering, fruiting and dispersion of species, both among individuals of the same species and among species, which complicates interpretation of fertile periods of the species.

During our study, we observed the inconsistent or erroneous identification of many species, which led to many collections being left out of the list presented here. These problems arise from the high plant diversity observed in the Amazon (Procópio and Secco 2008; Cysneiros *et al.* 2018), exacerbated by the scarcity of taxonomists and parobotanists dedicated to the knowledge and study of the regional flora (Cysneiros *et al.* 2018). Therefore, even though many species on the list are common in altered environments or yield commercial wood, identification is still precarious and insecure, leaving many species with uncertain identification (Cysneiros *et al.* 2018).

Field observations by the authors made clear the need for greater care in the process of determining species used in recovery/restoration processes. Without precise identification, the objectives of restoration/recovery work may be compromised, since silvicultural treatments are based on the specific requirements of the species. For example, in the north of Rondônia, a species locally called *ipê verde* is widely used in recovery/restoration processes of degraded areas, and for this reason it has great importance in one of the most degraded areas in the state. Collected testimony material was sent to a specialist who identified it as *G. aesculifolia*. Previously it had been treated as *Handroanthus* sp. There is great similarity among species of the genera *Handroanthus*, *Tabebuia* and *Godmania* (Johanes *et al.* 2022). The similarity is reflected by the popular denomination *ipê verde* given to these species, as it relates to shared morphological characteristics. Although it occurs naturally in the state, there are no records of this species in floristic works carried out in Rondônia. This fact may be due to the low accuracy of identification, which can have led the species to be mistakenly grouped with species of *Handroanthus*. The species has palmate leaves with 5-9 leaflets similar to those of *Handroanthus* and *Tabebuia* (Grose and Olmstead 2007). *Godmania* has fruits with spiral and striated capsules, and flowers with a campanulate corolla, and gibbous and hairy anthers (Grose and Olmstead 2007). Even with observable differences in the reproductive structures, the species was treated in processes of seed collection, seedling production and planting as *Handroanthus* and called *ipê verde*. The species has shown potential since 2010 for recovering degraded areas in

Rondônia, mainly due to its rapid growth and biomass gain in these areas (Paixão *et al.* 2023; unpubl. data).

A second positive bias to be considered when using *G. aesculifolia* in recovery/restoration processes is conservation actions. Its distribution extends from Mexico to central Brazil, both in savanna and tropical forest (Specieslink 2023; Tropics.org 2023). The species has 50 records in the Brazilian Amazon, Caatinga and Cerrado biomes (Lohmann 2023; Specieslink 2023), in the states of Acre, Rondônia, Mato Grosso, Pará, Goiás, Tocantins, Maranhão and Roraima (Specieslink 2023; SiBBR 2023). The records are in anthropized areas within urban perimeters by the Madeira River in the municipality of Porto Velho, and in pasture areas in Itapuá do Oeste (Specieslink 2023). The low number of *G. aesculifolia* records may be an indication that it is a rare species in Rondônia and its use in recovery/restoration processes contributed to its conservation in the region in the face of the advance of deforestation in the regions where the species is recorded. On the other hand, the higher number of occurrence records in *terra firme* forests is possibly due to the high richness of this environment in the Amazon (Oliveira and Mori 1999).

Thirteen species had proven occurrence in the *cerrado* habitats in the southern part of Rondônia (Silveira and Paixão 2019), which has been intensely altered, with extensive degraded abandoned areas that bear no more value for agriculture, livestock or forestry (Wandelli and Fearnside 2015; Silveira and Paixão 2019). These areas are challenging for restoration since they require species adapted to the restrictive conditions offered by the soils and seasonal climate of these savannas (Duboc *et al.* 2004; Silva *et al.* 2015). Therefore, having information on species adapted to these environments improves recovery efforts in a region where knowledge of native species among restoration professionals is still incipient.

## CONCLUSIONS

Lack of herbarium records and inconsistencies in the identification to species and, in some cases, to family level, were major hindrances in the definition of the list of species recommended for environmental restoration in this study. A major issue is that incorrectly identified species compromise the use of information and knowledge produced about them, which can limit the success of large-scale restoration projects in the state of Rondônia. Our study shows that there is a need for greater investment of time and resources in botanical surveys, herbarium records, taxonomic studies, phenological characterization, the formation of human resources in botanical taxonomy in Rondônia, as well as the development of identification keys and manuals and their dissemination in the restoration scene. As is true for the Amazon flora in general, most species selected as potentially suitable for the recovery of degraded areas belonged to Fabaceae, with wide occurrence in the different habitats in Rondônia. It was also evident that more studies are needed of the secondary

physiognomies for the knowledge of species that are successful in restored areas, in order to assist the actors involved in the ecological restoration/recovery of these areas, which will enable greater security and assertiveness in the processes of implementation of restoration/recovery actions.

## ACKNOWLEDGMENTS

The authors would like to thank the support received from the Rio Terra Study Center, the New York Botanical Garden-NYBG, the João Geraldo Kuhlmann Herbarium of Rondônia and the Postgraduate Program in Conservation and Use of Natural Resources – PPGReN of the Biology Department of the Universidade Federal de Rondônia.

## REFERENCES

- Albuquerque, A.C.S.; da Silva, A.G. 2008. *Agricultura Tropical: Quatro Décadas de Inovações Tecnológicas, Institucionais e Políticas*, v.2. Editora Embrapa Informação Tecnológica, Brasília, 700p.
- Andrade, L.R.B.; da Silva, J.A.A.; Marangon, L.C.; Ferreira, R.L.C.; da Silva, R.K.S. 2011. Sucessão ecológica de um trecho de floresta ombrófila densa de terras baixas, Carauari, Amazonas. *Pesquisa Florestal Brasileira* 31: 161-172.
- Barbosa, K.C.; Catharino, E.L.M.; Barbosa, L.M.; Couto, H.T.Z.D.; Santos, N.A.D. 2021. Potencial de regeneração natural de um plantio compensatório realizado em unidade de conservação urbana sob forte pressão antrópica. *Ciência Florestal* 31: 786-807.
- Barbosa, L.M.; Shirasuna, R.T.; Lima, F.C.; Ortiz, P.R.; Barbosa, K.C.; Barbosa, T.C. 2017. *Lista de Espécies Indicadas para Restauração Ecológica para Diversas Regiões do Estado de São Paulo*. Instituto de Botânica, São Paulo, 344p.
- Beltrame, T.P.; Rodrigues, E. 2007. Feijão guandu (*Cajanus cajan* (L.) Millsp.) na restauração de florestas tropicais. *Semina: Ciências Agrárias* 28: 19-28.
- Benini, R.; Santana, P.; Borgo, M.; Girão, V.; Campos, M.; Klein, F.; Gandolfi, S. 2016. *Manual de Restauração da vegetação nativa, Alto Teles, MT*. The Nature Conservancy, 114p. (<https://www.nature.org/media/brasil/manual-restauracao-mt.pdf>). Accessed on 09 Jul 2025.
- Cardoso, D.; Särkinen, T.; Alexander, S.; Amorim, A.M.; Bittrich, V.; Forzza, R.C.; *et al.* 2017. Amazon plant diversity revealed by a taxonomically verified species list. *Proceedings of the National Academy of Sciences* 114: 10695-10700.
- Chase, M.W.; Christenhusz, M.J.M.; Fay, M.F.; Byng, J.W.; Judd, W.S.; Soltis, D.E.; Mabberley, D.J.; Sennikov, A.N.; Soltis, P.S.; Stevens, P.F. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181: 1-20.
- Condé, T.M.; Tonini, H. 2013. Fitossociologia de uma floresta ombrófila densa na Amazônia Setentrional, Roraima, Brasil. *Acta Amazonica* 43: 247-259.
- Correia, F.W.; Manzi, A.; Candido, L.A.; Santos, R.M.N.; Pauliquevis, T.M. 2007. Balanço de umidade na Amazônia e sua sensibilidade às mudanças na cobertura vegetal. *Ciência e Cultura* 50: 39-43.

- Cysneiros, V.C.; Júnior, J.O.M.; Lanza, T.R.; Moraes, J.C.R.; Samor, O.J.M. 2018. Espécies madeireiras da Amazônia: riqueza, nomes populares e suas peculiaridades. *Pesquisa Florestal Brasileira* 38: 1-14. doi: 10.4336/2018.pfb.38e201801567
- Duboc, E. 2004. *Cultivo de Espécies Nativas do Bioma Cerrado*. Comunicado técnico. Embrapa Planaltina, DF, 10p. (<https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/569243>). Accessed on 23 Dec 2024.
- Fearnside, P.M. 1989. *A ocupação humana de Rondônia: impactos, limites e planejamento*. Programa Polonoroeste. Thecnical report #5, Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Brasília, 76p. ([https://philip.inpa.gov.br/publ\\_livres/1989/A%20Ocupacao%20Humana%20de%20Rondonia.pdf](https://philip.inpa.gov.br/publ_livres/1989/A%20Ocupacao%20Humana%20de%20Rondonia.pdf)). Accessed on 09 Jul 2025.
- Fearnside, P.M. 2005. Desmatamento na Amazônia brasileira: história, índices e consequências. *Megadiversidade* 1: 113-123.
- Fearnside, P.M. 2006. Desmatamento na Amazônia: dinâmica, impactos e controle. *Acta Amazonica* 36: 395-400.
- Flora e Funga do Brasil. 2023. Jardim Botânico do Rio de Janeiro. (<http://floradobrasil.jbrj.gov.br/>). Accessed on 9 Jul 2025.
- França, J.T. 1991. Estudo da sucessão secundária em áreas contíguas a mineração de cassiterita na Floresta Nacional do Jamari-RO. Master's dissertation, Universidade de São Paulo, Brasil, 169p. (<https://doi.org/10.11606/D.11.2019.tde-20191108-104520>).
- Grose, S.O.; Olmstead, R.G. 2007. Taxonomic revisions in the polyphyletic genus *Tabebuia* s.l. (Bignoniaceae). *Systematic Botany* 32: 660-670.
- IBGE. 2021. Instituto Brasileiro de Geografia e Estatística. Monitoramento da cobertura e uso da Terra, estatísticas desagregadas por unidades da federação 2000/2018. (<https://biblioteca.ibge.gov.br/visualizacao/livros/liv101790.pdf>). Accessed on 9 Jul 2025.
- Isernhagen, I. 2015. *Listagem Florística de Espécies Arbóreas e Arbustivas de Mato Grosso: Um Ponto de Partida para Projetos de Restauração Ecológica*. Embrapa Agrossilvipastoril, Sinop, 166 p.
- Johanes, I.; Costa, S.L.; Lohmann, L.G.; de Melo, J.I.M. 2022. Flora da Paraíba (Brasil): Aliança Tabebuia e Tribo Jacarandae (Bignoniaceae). *Iheringia, Série Botânica* 77: 1-18.
- Joly, C.A. 2007. Biodiversidade e mudanças climáticas: contexto evolutivo, histórico e político. *Ambiente & Sociedade* 10: 169-172.
- Klippel, V.H.; Pezzopane, J.E.M.; Silva, G.F.D.; Caldeira, M.V.W.; Pimenta, L.R.; Toledo, J.V. 2015. Avaliação de métodos de restauração florestal de Mata de Tabuleiros-ES. *Revista Árvore* 39: 69-79.
- Leão, N.V.M.; Carvalho, J.D.; Ohashi, S.T. 2001. Fenologia reprodutiva de 25 espécies arbóreas da Amazônia. In: Silva, JNM; Carvalho, JOP; Yared, JAG (Eds.) *A Silvicultura na Amazônia Oriental*. Embrapa Amazônia Oriental, Belém, p.117-128.
- Lima, R.M.B.; Souza, C.R.; Matschullat, J.; Silva, K.E. 2022. Recuperação de áreas degradadas ou alteradas na Amazônia. *Embrapa Amazônia Ocidental*, 157: 9-28.
- Lisboa, P.L.B. 1989. Estudo florístico da vegetação arbórea de uma floresta secundária, em Rondônia. *Boletim Museu Paraense Emílio Goeldi* 5: 145-162.
- Lohmann, L.G. 2023. *Godmania* in Flora e Funga do Brasil, Jardim Botânico do Rio de Janeiro. (<https://floradobrasil.jbrj.gov.br/FB114064>). Accessed on 9 Jul 2025.
- Mesquita, R.C.; Ickes, K.; Ganade, G.; Williamson, G.B. 2001. Alternative successional pathways in the Amazon Basin. *Journal of Ecology* 89: 528-537.
- Monaco, LM; Mesquita, RC; Williamson, GB 2003. Banco de sementes de uma floresta secundária amazônica dominada por *Vismia*. *Acta Amazonica* 33: 41-52.
- Nardoto, G.B.; Ometto, J.P.H.; Ehleringer, J.R.; Higuchi, N.; Bustamante, M.M.C.; Martinelli, LA 2008. Understanding the influences of spatial patterns on N availability within the Brazilian Amazon forest. *Ecosystems* 11: 1234-1246.
- Oliveira, A.A.; Mori, S.A. 1999. Uma floresta de terra firme da Amazônia central. I. Alta riqueza de espécies de árvores em solos pobres. *Biodiversity & Conservation* 8: 1219-1244.
- Paixão, K.R.C.; Silveira, A.L.P. 2020. O componente arbóreo de 1 ha de floresta de várzea no sudoeste da Amazônia, Rondônia, Brasil. *Brazilian Journal of Science of the Amazon* 9: 78-89.
- Piontekowski, V.J.; Matricardi, E.A.T.; Pedlowski, M.A.; Fernandes, L.C. 2014. Avaliação do desmatamento no estado de Rondônia entre 2001 e 2011. *Floresta e Ambiente* 21: 297-306.
- Procópio, L.C.; Secco, R.D.S. 2008. A importância da identificação botânica nos inventários florestais: o exemplo do "tauari" (*Couratari* spp. e *Cariniana* spp.-Lecythidaceae) em duas áreas manejadas no estado do Pará. *Acta Amazonica* 38: 31-44.
- PRODES. 2021. Instituto Nacional de Pesquisa Espaciais, Estimativa de desmatamento por corte raso na Amazônia Legal para 2021 é de 13.235 km<sup>2</sup>. (<http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>). Accessed on 9 Jul 2025.
- PRODES. 2024. Instituto Nacional de Pesquisa Espaciais, Monitoramento do Desmatamento da Floresta Amazônica Brasileira por Satélite. (<http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>). Accessed on 9 Jul 2025.
- Resh, S.C.; Binkley, D.; Parrotta, J.A. 2002. Greater soil carbon sequestration under nitrogen-fixing trees compared with *Eucalyptus* species. *Ecosystems* 5: 217-231.
- Ribeiro, S.S. 2016. *Avaliação da restauração florestal por meio de indicadores de monitoramento em áreas degradadas pela mineração de bauxita em Paragominas-PA*. Doctoral thesis, Universidade Federal Rural da Amazonia-UFRA, Brazil, 76p. (<http://repositorio.ufra.edu.br/jspui/handle/123456789/1202>).
- Rodrigues, R.R.; Brancalion, P.H.S.; Isernhagen, I. 2009. *Pacto Pela Restauração da Mata Atlântica: Referencial dos Conceitos e Ações de Restauração Florestal*. LERF/ESALQ/Instituto Atlântica, São Paulo, 256p.
- Sanquetta, C.R.; Sanquetta, M.N.I.; Bastos, A.; Queiroz, A.; Dalla Corte, A.P. 2017. Estimativa da altura e do volume em povoamentos jovens de restauração florestal em Rondônia. *BIOFIX Scientific Journal* 2: 23-31.
- Santos, A.S.; Silva, R.L.; Azevedo, A.L.; Oliveira, A.S.; Silva, A.E.; Silva, C.A. 2018. Riqueza florística de Fabaceae em diversos ecossistemas do município de Lábrea, estado do Amazonas, Brasil. *Cadernos de Agroecologia* 13: 1-7.
- Santos, E. 2014. *Manual de Procedimentos Gerais Para a Restauração Florestal no Estado do Espírito Santo*. Centro de Desenvolvimento do Agronegócio-CEDAGRO, Espírito Santo, 23p. (<https://cedagro>).

- org.br/artigos/MANUAL\_DIAGNOSTICO\_REGENERACAO\_NATURAL\_abr14.pdf). Accessed on 9 Jul 2025.
- Scotti, M.S.V., Biazatti, S.C., Júnior, J.F.B., Fagundes, S.T.S. 2020. Regeneração natural de espécies madeireiras na Amazônia Ocidental. *Revista Agroecossistemas* 11: 129-145.
- SiBBR. 2023. Sistema de Informação sobre a Biodiversidade Brasileira. Ocorrências por região. (<https://regions.sibbr.gov.br/regions/#rt=Biomass%20do%20Brasil>). Accessed on 9 Jul 2025.
- Siddique, I.; Engel, V.L.; Parrotta, J.A.; Lamb, D.; Nardoto, G.B.; Ometto, J.P.; Schmidt, S.; *et al.* 2008. Dominance of legume trees alters nutrient relations in mixed species forest restoration plantings within seven years. *Biogeochemistry* 88: 89-101.
- Silva, R.B.M.; Francelino, M.R.; Moura, P.A.; Moura, T.A.; Pereira, M.G.; de Oliveira, C.P. 2015. Relação solo/vegetação em ambiente de cerrado sobre influência do grupo Urucua. *Ciência Florestal* 25: 363-373.
- Silveira, A.L.P.; Paixão, K.R.C. 2019. Vegetação do estado de Rondônia. In: Lumbreras, J.F.; Silva, L.M.; Anjos, L.H. C.; Oliveira, V.A.V.; Wadt, P.G.; Pereira, M.G.; Delarmelinda-Honoré, E.A.; *et al.* (Eds.) *Guia de Campo da XII Reunião Brasileira de Classificação e Correlação de Solos: RCC de Rondônia*. Embrapa, Brasília. 531p.
- Souza, V.A.D.; Rotunno Filho, O.C.; Moreira, D.M.; Rudke, A.P.; Sá, M.R.T.D. 2019. Dinâmica do desmatamento na Amazônia e seus impactos na hidrologia: bacia do Rio Machado-Rondônia/Brasil. *Ciência Florestal* 29: 1004-1018.
- Specieslink.net. 2023. CRIA, Centro de Referência em Informação Ambiental. (<https://specieslink.net/>). Accessed on 9 Jul 2025.
- Sprent, J.I.; Platzmann, J. 2001. Nodulation in Legumes. Kew Publishing, Kew, 156p.
- ter Steege, H.; Pitman, N.C.; Sabatier, D.; Baraloto, C.; Salomão, R.P.; Silman, M.R.; and others. 2013. Hyperdominance in the Amazonian tree flora. *Science* 342: 1243092.
- ter Steege, H.; Vaessen, R.W.; Cárdenas-López, D.; Sabatier, D.; Antonelli, A.; De Oliveira, S.M.; Salomão, R.P. 2016. A descoberta da flora arbórea amazônica com uma lista atualizada de todos os táxons arbóreos conhecidos. *Relatórios Científicos* 6: 29549.
- Terrabrasilis. 2023. Monitoramento do Desmatamento da Floresta Amazônica Brasileira por Satélite – PRODES. Taxas de desmatamento. ([http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal\\_amazon/rates](http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/rates)). Accessed on 9 Jul 2025.
- Tropicos.org. 2023. Missouri Botanical Garden. (<https://tropicos.org/>). Accessed on 05 Feb 2026.
- UN. 2019. United Nations Decade on Ecosystem Restoration (2021–2030). General Assembly resolution 73/284 1 March 2019. (<https://docs.un.org/en/A/RES/73/284>). Accessed on 9 Jul 2025.
- Vieira, D.L.; Aquino, F.G.; Brito, M.A.; Fernandes-Bulhão, C.; Henriques, R.P. 2002. Síndromes de dispersão de espécies arbustivo-arbóreas em cerrado sensu stricto do Brasil Central e savanas amazônicas. *Brazilian Journal of Botany* 25: 215-220.
- Vieira, D.; Simon, M.; de Medeiros, M.B.; Rezende, G. 2021. *Árvores Recomendadas Para a Coleta de Sementes Para Recomposição da Vegetação Nativa das Áreas de Preservação Permanente (APP) da Usina Hidrelétrica (UHE) Jirau, Rondônia*. Technical report, Embrapa Recursos Genéticos e Biotecnologia, Brasília, 24p. (<https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1131776>). Accessed on 9 Jul 2025.
- Wandelli, E.V.; Fearnside, P.M. 2015. Secondary vegetation in central Amazonia: Land-use history effects on aboveground biomass. *Forest Ecology and Management* 347: 140-148.
- Watanabe, M.; de Oliveira, F.A.; Nunes, D.D.; da Silva Nunes, A.C.; de Aguiar Cavalcante, M.M.; de Aguiar, T.C. 2018. Análise do impacto do desmatamento no aporte sedimentar de bacias pareadas na Amazônia Ocidental: Bacias do rio Mutum-Paraná, Rondônia (Brasil). *Revista Brasileira de Geomorfologia* 19: 602-661.

RECEIVED: 23/08/2024

ACCEPTED: 30/06/2025

ASSOCIATE EDITOR: Geângelo Calvi 

**DATA AVAILABILITY:** The data that support the findings of this study were published in the article and in its attached supplementary material.

**AUTHOR CONTRIBUTIONS:** Késid Rafael Cavalcante Paixão

- conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing - original draft, writing - review & editing, visualization, supervision, project administration, funding acquisition; **Marcela Campanharo** - conceptualization, methodology, resources, investigation, writing - review & editing; **Antônio Laffayette Pires da Silveira** - conceptualization, methodology, formal analysis, investigation, resources, data curation, writing - original draft, writing - review & editing, supervision, funding acquisition.



## SUPPLEMENTARY MATERIAL

Paixão *et al.* Plant species indicated for the recovery of degraded areas in Rondônia, Brazil

**Table S1.** Ecological characterization of the species indicated for recovery of degraded areas in the state of Rondônia. Successional classification: P = pioneer, S = secondary, C = climax; Planting group: R = covering, D = diversity; Dispersion syndrome: Zoo = zoochoric, Ane = anemochoric, Bar = barochoric, Aut = autochoric. -- = unknown

Species	SC	PG	DS	Source
<i>Alchornea discolor</i> Poepp.	S	D	Zoo	Benini <i>et al.</i> 2016; Mesquita 2017; this study
<i>Anacardium spruceanum</i> Benth. ex Engl.	S	--	Zoo	Lima <i>et al.</i> 2011; Kuhlmann 2016
<i>Annona ambotay</i> Aubl.	P	--	Zoo	Condé and Tonini 2013; Kuhlmann 2016
<i>Aparisthium cordatum</i> (A.Juss.) Baill.	P	D	Aut	Oliveira <i>et al.</i> 2014; Figueiredo <i>et al.</i> 2015; Barbosa 2017
<i>Apeiba echinata</i> Gaertn.	P	R	Zoo	Rodrigues <i>et al.</i> 2015; Kuhlmann 2016
<i>Apeiba tibourbou</i> Aubl.	P	D	Zoo	Barbosa 2017
<i>Bauhinia acreana</i> Harms	P	D	Ane	Bioflora 2014; Ribeiro 2016; Souza <i>et al.</i> 2022
<i>Bellucia grossularioides</i> (L.) Triana	S	R	Zoo	Rodrigues <i>et al.</i> 2015; Zappi <i>et al.</i> 2018; Slobodzian <i>et al.</i> 2019
<i>Bertholletia excelsa</i> Bonpl.	S	D	Bar	Silva 2009; Condé and Tonini 2013; Bonavigo and Bastos 2018
<i>Bixa arborea</i> Huber	P	R	--	NBL and TNC 2013; Klippel <i>et al.</i> 2015
<i>Bixa orellana</i> L.	P	R	Zoo	Barbosa 2017
<i>Caryocar brasiliense</i> Cambess.	S	D	Zoo	Barbosa 2017; Silva <i>et al.</i> 2020
<i>Caryocar glabrum</i> (Aubl.) Pers.	S	R	Zoo	Amaral <i>et al.</i> 2009; this study
<i>Cassia grandis</i> L.f.	P	R	Aut	Barbosa 2017
<i>Cedrela odorata</i> L.*	C	D	Ane	Onofre <i>et al.</i> 2010; Barbosa 2017
<i>Copaifera langsdorffii</i> Desf.	S	D	Zoo	Corrêa <i>et al.</i> 2014; Barbosa 2017
<i>Cordia goeldiana</i> Huber	S	D	Zoo	Amaral <i>et al.</i> 2009; NBL and TNC 2013
<i>Couratari stellata</i> A.C.Sm.	C	--	Ane	Vaz 2011; Condé and Tonini 2013
<i>Dialium guianense</i> (Aubl.) Sandwith	S	D	Zoo	Condé and Tonini 2013; NBL and TNC 2013; Silva 2013
<i>Didymopanax morototoni</i> (Aubl.) Decne. & Planch.	P	D	Zoo	Barbosa 2017
<i>Dinizia excelsa</i> Ducke	C	--	Aut	Condé and Tonini 2013; this study
<i>Enterolobium maximum</i> Ducke	S	R	--	NBL and TNC 2013
<i>Eschweilera coriacea</i> (DC.) S.A.Mori	S	D	Bar	Amaral <i>et al.</i> 2009; Rodrigues <i>et al.</i> 2015
<i>Euterpe precatoria</i> Mart.	S	D	Zoo	Condé and Tonini 2013; Rodrigues <i>et al.</i> 2015; Passos <i>et al.</i> 2020
<i>Genipa americana</i> L.	S	D	Zoo	Barbosa 2017; Almeida and Viani 2020
<i>Godmania aesculifolia</i> (Kunth) Standl.	--	D	Ane	This study
<i>Goupia glabra</i> Aubl.	S	D	Zoo	Amaral <i>et al.</i> 2009; NBL and TNC 2013
<i>Guazuma ulmifolia</i> Lam.	P	R	Zoo	Rozza 1997; Rodrigues <i>et al.</i> 2015; Almeida and Viani 2020
<i>Handroanthus serratifolius</i> (Vahl) S.Grose	S	D	Ane	Barbosa 2017; Almeida and Viani 2020
<i>Hevea brasiliensis</i> (Willd. ex A.Juss.) Müll.Arg.	S	R	Bar	Rodrigues <i>et al.</i> 2015; this study
<i>Hymenaea courbaril</i> L.	S	D	Zoo	Barbosa 2017; Almeida and Viani 2020
<i>Inga alba</i> (Sw.) Willd.	S	R	Zoo	Amaral <i>et al.</i> 2009; Benini <i>et al.</i> 2016
<i>Inga edulis</i> Mart.	S	R	Zoo	Amaral <i>et al.</i> 2009; Barbosa 2017
<i>Inga marginata</i> Willd.	S	R	Zoo	Amaral <i>et al.</i> 2009; Barbosa 2017
<i>Inga umbratica</i> Poepp. & Endl.	P	R	Zoo	Alfaro and Trojan 2017; Barbosa 2021; this study
<i>Jacaranda copaia</i> (Aubl.) D.Don	P	D	Ane	Amaral <i>et al.</i> 2009; NBL and TNC 2013
<i>Mabea speciosa</i> Müll. Arg.	P	D	Bar	Amaral <i>et al.</i> 2009; Benini <i>et al.</i> 2016
<i>Maprounea guianensis</i> Aubl.	S	D	Zoo	Stefanello <i>et al.</i> 2010; Barbosa 2017
<i>Mezilaurus itauba</i> (Meisn.) Taub. ex Mez	S	D	Zoo	Amaral <i>et al.</i> 2009; Benini <i>et al.</i> 2016
<i>Miconia dispar</i> Benth.	S	--	Zoo	Costa 2006; Silva 2011
<i>Miconia poeppigii</i> Triana	S	--	--	Cavalheiro <i>et al.</i> 2021
<i>Muntingia calabura</i> L.	P	R	Zoo	Beltrame and Rodrigues 2007; Lapo <i>et al.</i> 2015; this study
<i>Naiadendron duckeanum</i> (Occhioni) A.G. Lima, Paula-Souza & Scalon, comb. nov.	P	R	Aut	Scalon 2007; this study

**Table S1.** Continued.

Species	SC	PG	DS	Source
<i>Ochroma pyramidale</i> (Cav. ex Lam.) Urb.	P	R	Ane	Barbosa <i>et al.</i> 2021; Neto 2023
<i>Peltogyne paniculata</i> Benth.	S	--	--	Lima <i>et al.</i> 2011
<i>Pourouma villosa</i> Trécul	P	--	Zoo	Amaral <i>et al.</i> 2009
<i>Pouteria caimito</i> (Ruiz & Pav.) Radlk.	S	D	Zoo	Amaral <i>et al.</i> 2009; Barbosa 2017
<i>Qualea paraensis</i> Ducke	S	D	Bar	Amaral <i>et al.</i> 2009; Miranda <i>et al.</i> 2020
<i>Schizolobium parahyba</i> (Vell.) Blake	P	D	Ane	Nave 2005; Nave and Rodrigues 2007
<i>Simarouba amara</i> Aubl.	S	R	Zoo	Ferraz <i>et al.</i> 2004; Condé and Tonini 2013; NBL and TNC 2013
<i>Stryphnodendron pulcherrimum</i> (Willd.) Hochr.	P	D	--	NBL and TNC 2013; this study
<i>Tachigali guianensis</i> (Benth.) Zarucchi & Herend.	P	--	Ane	Amaral <i>et al.</i> 2009; Condé and Tonini 2013
<i>Tapirira guianensis</i> Aubl.	P	D/R	Zoo	Amaral <i>et al.</i> 2009; Oliveira <i>et al.</i> 2014
<i>Theobroma grandiflorum</i> (Willd. ex Spreng.) K.Schum.	S	D	Zoo	Lima 2002; Amaral <i>et al.</i> 2009
<i>Trema micrantha</i> (L.) Blume	P	R	Zoo	Ribas and Kageyama 2004; NBL and TNC 2013

## REFERENCES

- Alfaro, A.T.S.; Trojan, D.G. 2017. *Descobertas das Ciências Agrárias e Ambientais 3*. Atena Editora. Ponta Grossa, 356p.
- Almeida, C.; Viani, R.A.G. 2020. *Tree Species Planted for the Atlantic Forest Restoration: A Floristic and Functional Analysis (version 2)*. Technical report, LASPEF-UFSCar, Universidade Federal de São Carlos, Brazil. (<https://laspef.com.br/wpcontent/uploads/2020/05/Almeida-e-Viani-2020-especies-plantadas-na-restauracao-MataAtlantica.pdf>). Accessed on 10 Jul 2025.
- Amaral, D.D.; Vieira, I.C.G.; de Almeida, S.S.L.; Jardim, M.A.G. 2009. Checklist da flora arbórea de remanescentes florestais da região metropolitana de Belém e valor histórico dos fragmentos, Pará, Brasil. *Boletim do Museu Paraense Emílio Goeldi-Ciências Naturais* 4: 231-289.
- Barbosa, K.C.; Catharino, E.L.M.; Barbosa, L.M.; Couto, H.T.Z.D.; Santos, N.A.D. 2021. Potencial de regeneração natural de um plantio compensatório realizado em unidade de conservação urbana sob forte pressão antrópica. *Ciência Florestal* 31: 786-807.
- Barbosa, L.M. (org.). 2017. *Lista de Espécies Indicadas para Restauração Ecológica para Diversas Regiões do Estado de São Paulo*, Instituto de Botânica, São Paulo, 344p. (<https://www.infraestruturameioambiente.sp.gov.br/institutodebotanica/wp-content/uploads/sites/235/2019/10/lista-especies-rad-2019.pdf>). Accessed on 10 Jul 2025.
- Barbosa, R.D.S. 2021. Técnicas de restauração florestal em áreas mineradas e definição de espécies chaves para a Amazônia Oriental. Doctoral thesis, Universidade Federal Rural da Amazônia, Brazil, 83p. (<https://repositorio.ufra.edu.br/jspui/handle/123456789/1175>).
- Beltrame, T.P.; Rodrigues, E. 2007. Feijão guandu (*Cajanus cajan* (L.) Millsp.) na restauração de florestas tropicais. *Semina: Ciências Agrárias* 28: 19-28.
- Benini, R.; Santana, P.; Borgo, M.; Girão, V.; Campos, M.; Klein, F.; *et al.* 2016. *Manual de Restauração da Vegetação Nativa, Alto Teles Pires, MT*. Technical report, The Nature Conservancy, 136p. (<https://www.nature.org/media/brasil/manual-restauracao-mt.pdf>). Accessed on 10 Jul 2025.
- Bioflora. 2014. *Manual Técnico Operativo de Restauração Florestal do Estado do Pará*. Technical report, Bioflora Tecnologia da Restauração, Belém, 95p. (<https://pt.scribd.com/document/532768085/MANUAL-TECNICO-OPERATIVO-DE-RESTAURACAO-FLORESTAL-DO-ESTADO-DO-PARA>). Accessed on 10 Jul 2025.
- Bonavigo, P.H.; Bastos, A. 2018. *Manual de Regularização Ambiental das Propriedades Rurais do Estado de Rondônia* (preliminary version). Technical report, SEDAM-RO/GIZ/Centro de Estudos Rioterra, Porto Velho, 76p. (<https://www.portaldocodigo.org/prarondonia/Manual%20t%C3%A9cnico%20do%20Programa%20de%20Regulariza%C3%A7%C3%A3o%20Ambiental%20do%20Estado%20de%20Rond%C3%B4nia.pdf>). Accessed on 10 Jul 2025.
- Cavalheiro, W.C.S.; Scoti, M.S.V.; Vendruscolo, J.; dos Santos, J.A. 2021. Caracterização da floresta ombrófila aberta submontana na Rebio Guaporé, Amazônia Ocidental, Brasil. *Nature and Conservation* 14: 175-184.
- Condé, T.M.; Tonini, H. 2013. Fitossociologia de uma floresta ombrófila densa na Amazônia Setentrional, Roraima, Brasil. *Acta Amazonica* 43: 247-259.
- Corrêa, L.S.; Cardoso-Leite, E.; Koch, I. 2014. Estrutura, composição florística e caracterização sucessional em remanescente de Floresta Estacional Semidecidual no Sudeste do Brasil. *Revista Árvore* 38: 799-809.
- Costa, L.T.D. 2006. Estratégias de reabilitação de áreas degradadas em empreendimentos hidrelétricos na Amazônia, Tucuruí-PA. Master's dissertation, Universidade Federal Rural do Rio de Janeiro, Brazil, 95p. (<https://rima.ufrrj.br/jspui/handle/20.500.14407/11386>).
- Ferraz, I.D.K.; Leal Filho, N.; Imakawa, A.M.; Varela, V.P.; Piña-Rodrigues, F. 2004. Características básicas para um agrupamento ecológico preliminar de espécies madeireiras da floresta de terra firme da Amazônia Central. *Acta Amazonica* 34: 621-633.
- Figueiredo, L.T.M.; Soares, C.P.B.; Sousa, A.L.D.; Leite, H.G.; Silva, G.F.D. 2015. Dinâmica do estoque de carbono em fuste de árvores de uma floresta estacional semidecidual. *Cerne* 21: 161-167.
- Klippel, V.H.; Pezzopane, J.E.M.; Silva, G.F.D.; Caldeira, M.V.W.; Pimenta, L.R.; Toledo, J.V. 2015. Avaliação de métodos de

- restauração florestal de Mata de Tabuleiros-ES. *Revista Árvore* 39: 69-79.
- Kuhlmann, M.P. 2016. Estratégias de dispersão de sementes no bioma Cerrado: considerações ecológicas e filogenéticas. Doctoral thesis, Universidade Federal de Brasília, Brazil, 360p. ([https://repositorio.unb.br/bitstream/10482/20631/1/2016\\_MarceloKuhlmannPeres.pdf](https://repositorio.unb.br/bitstream/10482/20631/1/2016_MarceloKuhlmannPeres.pdf)).
- Lapo, C.A. 2015. Aspectos ecológicos da arborização de três bairros centrais do município de Santos-SP. Master's dissertation, Universidade Santa Cecília, Brazil, 81p. ([https://sites.unisantabr/ppgecomar/dissertacoes/Dissertacao\\_Christian.pdf](https://sites.unisantabr/ppgecomar/dissertacoes/Dissertacao_Christian.pdf)).
- Lima, M.M. 2002. Crescimento, composição mineral e sintomas de deficiência de macronutrientes em plantas de cupuaçuzeiro (*Theobroma grandiflorum*). Master's dissertation, Universidade Federal Rural da Amazônia, Brazil, 77p. (<https://ainfo.cnptia.embrapa.br/digital/bitstream/item/61112/1/Martinha.pdf>).
- Lima, R.B.; da Silva, J.A.A.; Marangon, L.C.; Ferreira, R.L.C.; da Silva, R.K.S. 2011. Sucessão ecológica de um trecho de floresta ombrófila densa de terras baixas, Carauari, Amazonas. *Pesquisa Florestal Brasileira* 31: 161-172.
- Mesquita, R.D. 2017. Dispersão de sementes por aves em área aberta e fragmento florestal urbano na Amazônia Sul-ocidental. Master's dissertation, Universidade Federal do Acre, Brazil, 105p. (<https://www.ufac.br/cita/o-programa/dissertacoes/2017/rosiane-portela-de-mesquita.pdf>).
- Miranda, E.; Malta, E.; Vieira, D.L.M.; Rocha, G.; Ferreira, M.; Pachêco, B.; et al. 2020. *Espécies para semeadura direta na Amazônia, Cerrado e Mata Atlântica*. Technical report, Agroicone, São Paulo, 108p. ([https://www.agroicone.com.br/wp-content/uploads/2021/04/especies\\_ameaduradireta.pdf](https://www.agroicone.com.br/wp-content/uploads/2021/04/especies_ameaduradireta.pdf)). Accessed on 10 Jul 2025.
- Nave, A.G. 2005. Banco de sementes autóctone e alóctone, resgate de plantas e plantio de vegetação nativa na fazenda Intermontes, município de Ribeirão Grande, SP. Doctoral thesis, Escola Superior de Agricultura Luiz de Queiroz/Universidade de São Paulo, Brazil, 218p. (<https://www.teses.usp.br/teses/disponiveis/11/11150/tde-02062005-153506/en.php>).
- Nave, A.G.; Rodrigues, R.R. 2007. Combination of species into filling and diversity groups as forest restoration methodology. In: Rodrigues, R.R.; Gandolfi, S. (Eds.). *High diversity forest restoration in degraded areas: methods and projects in Brazil*. Nova Science Publishers, New York, p.103-126.
- NBL; TNC. 2013. *Manual de Restauração Florestal: Um Instrumento de Apoio à Adequação Ambiental de Propriedades Rurais do Pará*. Technical report, Engenharia Ambiental Ltda/The Nature Conservancy, Belém, 128p. (<https://www.nature.org/media/brasil/manual-de-restauracao-florestal.pdf>). Accessed on 10 Jul 2025.
- Neto, A.B. 2023. Efeitos da restauração florestal sobre os atributos do solo e da vegetação após a mineração de bauxita em Paragominas, Pará. Doctoral Thesis, Universidade Federal Rural da Amazônia, Brazil, 81p. (<https://repositorio.ufra.edu.br/jspui/handle/123456789/1951>).
- Oliveira, A.K.M.; Resende, U.M.; Schleder, E.J.D. 2014. Espécies vegetais e suas síndromes de dispersão em um remanescente de Cerrado (sentido restrito) do município de Campo Grande, Mato Grosso do Sul. *Ambiência* 10: 565-580.
- Onofre, F.F.; Engel, V.L.; Cassola, H. 2010. Natural regeneration of Atlantic Forest species in the understory of Eucalyptus saligna Smith. in a former forest production unit at the parque das Neblinas, Bertioga, SP. *Scientia Forestalis* 38: 39-52.
- Passos, V.T.R.; da Silva, H.A.; da Costa, M.M. 2020. Capacidade de dispersão e autopropagação de espécies arbóreas cultivadas no Parque Zoológico da Universidade Federal do Acre. *Scientia Naturalis* 2: 455-468.
- Ribas, L.A.; Kageyama, P.Y. 2004. Diversidade e estrutura genética em populações naturais de *Trema micrantha* (L.) B. *Scientia Forestalis* 66: 66-75.
- Ribeiro, S.S. 2016. Avaliação da restauração florestal por meio de indicadores de monitoramento em áreas degradadas pela mineração de bauxita em Paragominas-PA. Master's dissertation, Universidade Federal Rural da Amazônia, Brazil, 75p. (<https://repositorio.ufra.edu.br/jspui/handle/123456789/1202>).
- Rodrigues, R.R.; Nave, A.G.; Gandolfi, S.; Molina, D.; Isernhagen, I.; Copetti, L. 2015. *Cartilha de Restauração Florestal de Áreas de Preservação Permanente, Alto Teles Pires, MT*. Technical report, The Nature Conservancy, 100p. (<https://www.passeidireto.com/arquivo/116841925/manual-de-restauracao-florestal-de-areas-de-preservacao-permanente-alto-teles-pi?>). Accessed on 10 Jul 2025.
- Rozza, A.F. 1997. Florística, fitossociologia e caracterização sucessional em uma floresta estacional semidecidual: Mata da Virginia, Matão, SP. Master's dissertation, Universidade Estadual de Campinas, Brazil, 177p. (<https://repositorio.unicamp.br/Acervo/Detalle/134458>).
- Scalon, V.R. 2007. Revisão taxonômica do gênero *Stryphnodendron* Mart. (Leguminosae-Mimosoideae). Doctoral thesis, Universidade de São Paulo, Brazil, 264 p. (<https://www.teses.usp.br/teses/disponiveis/41/41132/tde-29012008-113442/pt-br.php>).
- Silva, A.C.C. 2009. Remoção e destino de sementes de *Carapa guianensis* Aubl. (Meliaceae) e *Bertholletia excelsa* Bonpl. (Lecythidaceae) no sudoeste do Estado do Acre, Brasil. Master's Dissertation, Universidade Federal do Acre, Brazil, 153p. ([http://www.dominiopublico.gov.br/pesquisa/DetalleObraForm.do?select\\_action=&coobra=182053](http://www.dominiopublico.gov.br/pesquisa/DetalleObraForm.do?select_action=&coobra=182053)).
- Silva, J.M. 2013. Floresta urbana: síndrome de dispersão e grupos ecológicos de espécies do sub-bosque. *Boletim de Geografia* 31: 135-144.
- Silva, J.M.D. 2011. Regeneração natural das clareiras antrópicas da Província Petrolífera de Uruçu-Coari, AM. Master's Dissertation, Instituto Nacional de Pesquisas da Amazônia-INPA, Brazil, 125p. ([https://bdtd.ibict.br/vufind/Record/INPA-2\\_e4d97bc9e8d2dc0dcbbe612bd8303f8a](https://bdtd.ibict.br/vufind/Record/INPA-2_e4d97bc9e8d2dc0dcbbe612bd8303f8a)).
- Silva, L.S.; Otoni, T.J.O.; Vieira, A.D.; Gonzaga, A.P.D.; Pereira, I.M.; Machado, E.M.; Franco, S.A.P. 2020. Dinâmica de populações arbóreas em fitofisionomias de Cerrado e de Floresta Estacional Semidecidual. *Scientia Forestalis* 48: e3300.
- Slobodzian, N.; Chambó, E.D.; Pinto, M.N.; Lima, R.A. 2019. Fitossociologia em trecho de mata ciliar do Instituto de Natureza e Cultura no município de Benjamin Constant-AM. *South American Journal of Basic Education, Technical and Technological* 6: 128-144.

- Souza, L.A.; Ribeiro, S.B.; Scoti, M.S.V.; Moreto, R.F.; Júnior, N.R.F.S. 2022. Seleção de espécies florestais para a restauração ecológica em nascentes degradadas na Zona da Mata de Rolim de Moura. *Revista Ibero-Americana de Ciências Ambientais* 13: 1-9.
- Stefanello, D.; Ivanauskas, N.M.; Martins, S.V.; Silva, E.; Kunz, S.H. 2010. Síndromes de dispersão de diásporos das espécies de trechos de vegetação ciliar do rio das Pacas, Querência-MT. *Acta Amazonica* 40: 141-150.
- Vaz, M.C. 2011. Diversidade de estratégias ecológicas das espécies de árvore dominantes de uma floresta de terra firme da Amazônia Central. Doctoral thesis, Universidade de São Paulo, Brazil, 109p. (<https://www.teses.usp.br/teses/disponiveis/41/41134/tde-19012012-161354/pt-br.php>).
- Zappi, D.C.; Gastauer, M.; Ramos, S.; Nunes, S.; Caldeira, C.F.; Souza-Filho, P.W.; *et al.* 2018. Plantas Nativas para Recuperação de Áreas de Mineração em Carajás. Technical report, Instituto Tecnológico Vale, 286p. (<https://www.itv.org/wp-content/uploads/2019/11/RADCarajas.pdf>). Accessed on 10 Jul 2025.