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RESEARCH ARTICLE

Applying a floristic originality index in tropical forests of south Sinaloa, Mexico

Aplicando um índice de originalidade florística em florestas tropicais do sul de Sinaloa, México

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Abstract

Sinaloa is among the states of Mexico harboring the highest deforestation rates. Reforestation programs have been put up in south Sinaloa with species chosen for their high seedling rates, structural importance or strong restoration value. However, species criteria such as level of endemism as well as rarity appear to be underestimated. Eight sampling sites were randomly selected and a botanical survey was carried out at least every month from 2015 to 2017. In order to rank species over conservation stakes, a Floristic Originality Index method was elaborated using species level of endemism, rarity and conservation status. The floristic inventory enabled the identification of a set of 250 species with the Fabaceae being the most represented family with 51 species. Using the Floristic Originality Index, a subset of 51 species was selected as priority for conservation along with 23 other species all displaying characteristics of "framework" species. Features of reproduction and types of ideal soil conditions for reforestation are presented for each species. The method developed to determine floristic originality has proven a set of most vulnerable and rare species to select "priority" and "framework" tree species able to restore forests structure and biodiversity as well as ecosystem functions. This evaluation is made from a conservation biology point of view and appears to be well adapted for studies at a local scale.

Resumo
Sinaloa é um dos estados com o maior índice de desmatamento no México. Programas de reflorestamento têm sido implantados na porção sul, utilizando espécies com taxas de plântulas elevadas, importância estrutural ou alto valor de restauração. No entanto, critérios como níveis de endemismo e raridade das espécies parecem estar subestimados. Neste trabalho, realizou-se um inventário florístico, ao menos a cada mês, durante três anos (2015–17) em oito locais de amostragem selecionados aleatoriamente. Elaborou-se um método de Índice de Originalidade Florística, utilizando nível de endemismo de espécies, raridade e estado de conservação para classificar espécies raras. O inventário florístico resultou em um conjunto de 250 espécies identificadas, sendo Fabaceae (S=51) a família com o maior número de espécies. Usando o Índice de Originalidade Florística, um subconjunto de 51 espécies foi selecionado como prioritário para a conservação, somando-se a 23 outras espécies que exibem todas as características de espécies "framework". Características de reprodução e os tipos de condições ideais de solo para o reflorestamento de cada espécie são apresentadas. O método desenvolvido para determinar a originalidade provou um conjunto de espécies mais vulneráveis e raras para selecionar espécies de árvores "prioritárias" e "estruturais" capazes de restaurar a estrutura e a biodiversidade das florestas, bem como as funções do ecossistema. Esta avaliação é feita do ponto de vista da biologia da conservação e está bem adaptada para estudos em nível local.

Keywords
conservation priorities, endemism, flora composition, framework species, rarity, tropical forest, wild vegetation

Palavras-chave
composição florística, endemismo, espécie de estrutura, floresta tropical, prioridades de conservação, raridade, vegetação nativa

Introduction

The global concern about the reduction of tropical forests due to human activities is increasing. According to recent studies (Wright and Muller-Landau 2006; Elliott et al. 2013; Chazdon 2014) some 35 to 50% of the surface areas of these plant communities has been destroyed worldwide. The main consequences are usually: soil Carbon and Nitrogen stock loss (Assefa et al. 2017), effects on trophic interactions, hydrological alterations (Runyan and D'Odorico 2016), increasing of temperatures and diseases (Kweka et al. 2016), as well as biodiversity loss (Geist and Lambin 2002; Addo-Fordjour et al. 2009; Mwakalukwa et al. 2014; Egbinola 2015). The latest is associated with patterns of human activity (Sala et al. 2000) because the climax ecosystems are replaced by secondary vegetation, with an obvious weakening of the vegetation structure and floristic composition (Corlett 1994).

Such phenomena can be illustrated in the example of the state of Sinaloa, Mexico, where 4% of temperate and tropical forest has vanished between 1993 and 2011 with an average annual rate of deforestation of 0.41% (Monjardín-Armenta et al. 2017). This places Sinaloa among the 15 states with the highest rate of deforestation in Mexico (Aguilar-Sierra et al. 2000). Agriculture and livestock farming are the main identified factors for this loss (Monjardín-Armenta et al. 2017). In response to this concern, reforestation programs have been put up by institutions such as CONAFOR (Comisión Nacional Forestal), PRONATURA A. C., CONSELVA A. C., FONATUR (Fondo Nacional de Fomento al Turismo), among others. In general, the criteria used to select reforestation species are high seedling rates, structural importance or high restoration value. However, other important criteria such as species levels of endemism as well as rarity appear to be underestimated (Forest Restoration Research Unit 2000).

With an overall floristic richness reaching 3737 species (Villaseñor-Ríos 2016; Amador-Cruz et al. 2017), the state of Sinaloa harbors a great variety of vegetation types. Four major vegetation types can be distinguished in Sinaloa tropical forests: (i) dry forest, (ii) semideciduous forest, (iii) cloud forest, and (iv) mangroves (Whitmore 1998; Vega-Aviña et al. 2000; Elliott et al. 2013; INEGI 2013; CONAFOR 2014). Although most of these ecosystems are located in northern Sinaloa, the southern part of the state harbors the largest area of semideciduous forest, considered as more diverse (CONAFOR 2014); in addition, the mangroves in the south are the most preserved of the entire Pacific coast of Mexico (CONANP 2008). Both plants communities, as well as dry forest, are found in the Region of Palmito de Verde (RPV), which includes the municipalities of Escuinapa and Rosario.

The aim of this study is to determine a set of most vulnerable and rare species through a modified Floristic Originality Index (Rabinowitz 1981; Rabinowitz et al. 1986) in order to select "framework" tree species able to restore forests' structure and biodiversity as well as ecosystem functions (Forest Restoration Research Unit 2000). The modification consists of implementing the "Threat" criteria that is now taken into account in public policies of vulnerable species protection. This attribute can be considered as essential for conservation since the selection of a species within this list leads to a meticulous study of the population's distribution and inter and intraspecific relationships (IUCN 2001; SEMARNAT 2010; Sánchez-Salas et al. 2013).

Methods

Study area

In the southern part of the state of Sinaloa (Fig. 1), the Region of Palmito de Verde (municipalities of Escuinapa and Rosario) is part of a RAMSAR site (Marismas Nacionales, number 732). It has a tropical climate with significant summer rainfall and can be classified as of Awo (w)(e) type (García 2004; Servicio Meteorológico Nacional 2010). Furthermore, four main soil types can be distinguished, from most to least common (i) hiposalic gleyic Arenosol /Regosol, (ii) hypersodic gleyic Solonchak, (iii) eutric epileptic Cambisol, and (iv) hiposodic hiposalic Phaeozem, the first mostly in semideciduous forests, the second in mangroves, the third in dry forest and the last in riparian vegetation (INEGI 2014).

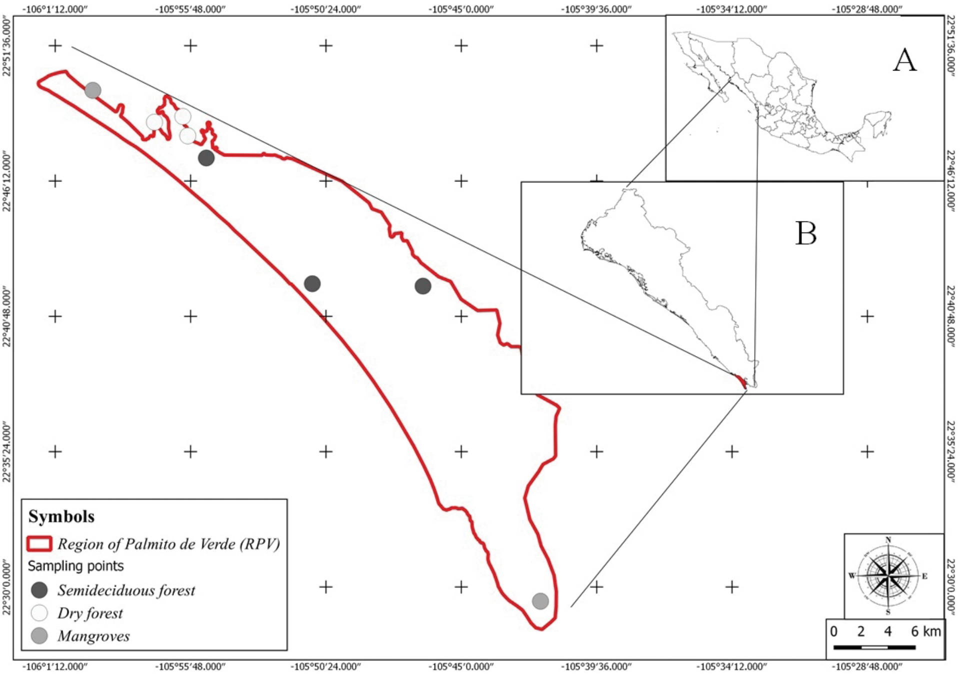

Figure 1. Map of the study area (Region of Palmito de Verde), sampling sites by vegetation type. **A** Mexico; **B** state of Sinaloa. Background map INEGI (1995, 2016).

Sampling points

Satellite images were used to identify the area best representing primary mangroves and dry or semideciduous forest vegetation. Through use of the 'random points inside polygons' tool, in QGIS2.18.7 Las Palmas de G.C., eight sampling sites were randomly selected within the area covered by vegetation. With the intention to produce a floristic inventory, in each sampling point a plot of 400 m^2, with three repetitions, was established (Phillips et al. 2003). A botanical survey was conducted every month, alternating the collecting site during 27 months (2015–2017), in order to cover the full phenology and gather a collection of fertile specimens for the plant species on site (Shaheen et al. 2014) (Figs 1, 2). Over 600 herbarium specimens were collected, mostly flowering and fruiting, but some sterile specimens were also collected for more common and well-known species (Gonçalves and Goyder 2016). The geographical coordinates, collector's name, date, habitat, phenology, and other features are provided on voucher labels (Shaheen et al. 2014; Luize et al. 2015). Botanical specimens have been deposited at herbarium Jesús González Ortega of the Autonomous University of Sinaloa (acronym: UAS) and Herbarium of Center for Research in Food and Development (acronym: HCIAD), both located in the state of Sinaloa, Mexico. The nomenclature used is that proposed by Tropicos (2019).

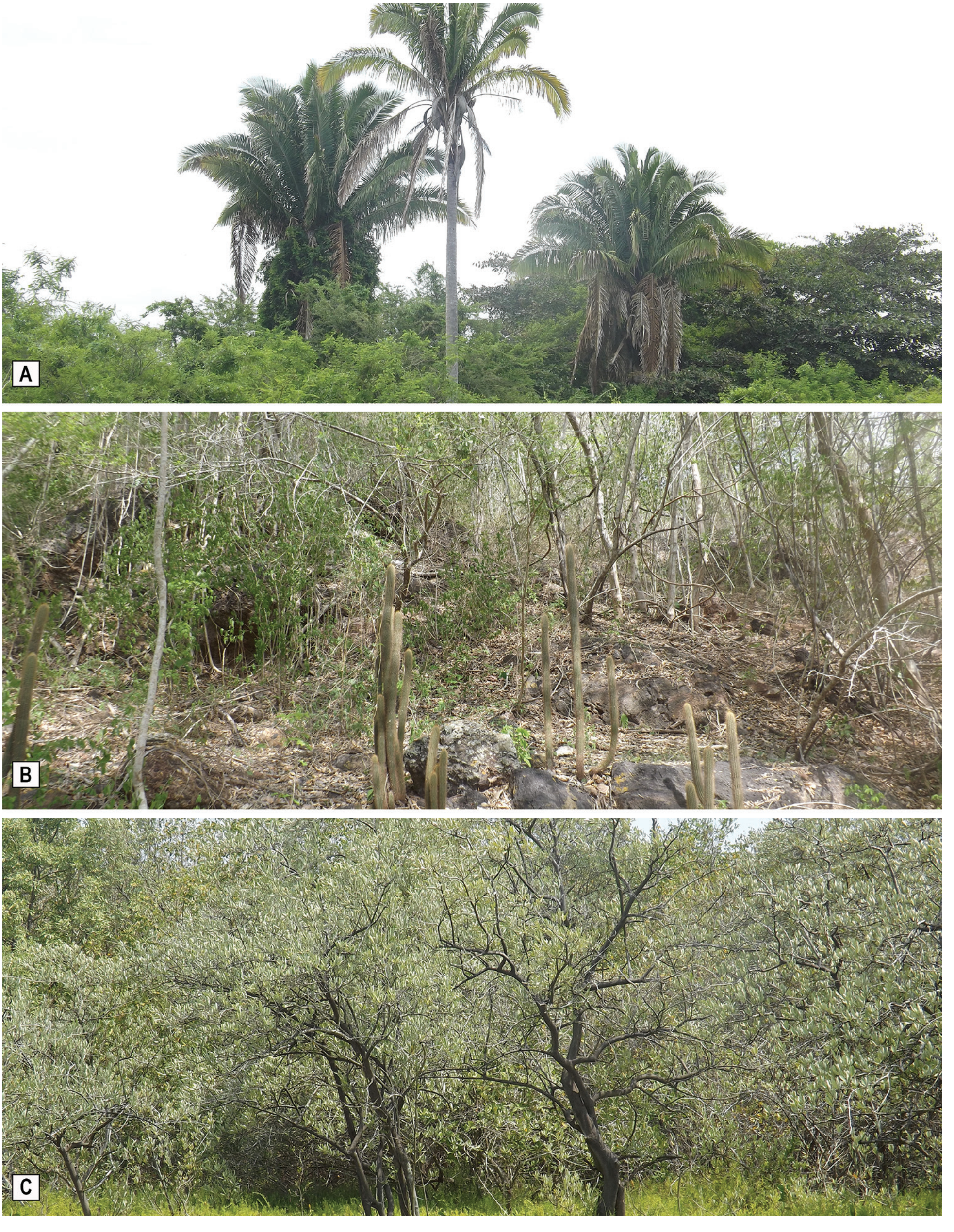

Figure 2. Types of tropical vegetation in the Region of Palmito de Verde, state of Sinaloa, Mexico: **A** semideciduous forest, **B** dry forest, **C** mangroves.

Floristic Originality Index (FOI)

The method developed by Rabinowitz to determine levels of originality is very useful to evaluate the rarity of the species at the local level, under the premise that if the causes of the rarity of some species are diverse, the ecological effects could be equally diverse (Kruckeberg and Rabinowitz 1985; Broennimann et al. 2005). However, the ranking of most species through IUCN categories is yet to be achieved in some regions. Hence, the need for operational tools to guide public policies over biodiversity protection and restoration requires the implementation of the "Threat" criteria to assign a practical conservation value that can be used by government institutions (SEMARNAT 2010), international bodies (IUCN 2016; CITES 2017) and NGO's. The Floristic Originality Index method developed herein modifies Rabinowitz's rare species ranking system (Rabinowitz 1981; Rabinowitz et al. 1986): it takes into account the species threat level at the region scale, in addition to distribution range, endemism, and rarity.

To avoid a double assignment, species were sorted as Threatened or Not Threatened. The first case included all species that have some category of vulnerability according to the NOM-059 (SEMARNAT 2010), in categories equivalent to those of IUCN (2001) or incorporated in some appendix of CITES (2017) (Table 1).

To assign a value to the "Threat" criteria, three possible scales were investigated, of which two were linear models and the other was over a base 2 exponential (Table 2), considering that rarity is likely not linear since the causes of species dwindling are multi-factor (Rabinowitz 1981). Furthermore, a minimum value of 1 was assigned to every species, in order to acknowledge its intrinsic value and to include "ordinary" biodiversity in conservation topic (Gaston and Fuller 2007; Devineau et al. 2009; Godet 2010; Brédif and Simon 2014; Couvet and Ducarme 2014; Couvet and Vandevelde 2014). Subsequent values were plotted using the R 3.0.0. software (R Core Team 2017), to compare alternative progression trends (Fig. 3).

At the beginning, the "x" value in the three functions was similar, and the threat value remains nearly identical at $x = 3$. However, the exponential function model fits the expected progression better since the threat value rises slightly with $x = 4$ and more obviously with $x > 5$. Hence, the exponential model was eventually chosen as it provides a relevant starting point as to when to consider a species as a conservation priority.

The considered criteria were limited to the following characteristics (Rabinowitz 1981; Kruckeberg and Rabinowitz 1985; Broennimann et al. 2005):

Geographic range – *Large*: the distribution of the species was large in the country, or was cosmopolite, *Restricted range endemic*: the species was distributed only on the Pacific coast of Mexico, or was only present in the states surrounding Sinaloa.

Habitat specificity – *Wide*: the species had the ability to develop in various types of vegetation, *Narrow*: the species grew in only one, or two types of vegetation (eco-endemic).

Table 1. Categories included in "Threat" criteria. Categories in the same row are equivalents.

NOM-059 (SEMARNAT 2010)	Category of The Red List (IUCN, 2001)	CITES (2017)
Special Protection (Pr)	Near Threatened (NT)	–
Threatened (A)	Vulnerable (VU)	–
	Endangered (EN)	–
Endangered (P)	Critically Endangered (CR)	–
		Appendices I
		Appendices II

Table 2. Species rarity values including a "Threat" criteria, assigned with 3 different scale models.

		Geographic range	Large		Small (restricted range endemic)	
		Habitat specificity	Wide	Narrow	Wide	Narrow
Local population size	Large, dominant by places	Not Threatened	1	2	3	4
		Threatened	**3**	**4**	**5**	**6**
			2	**4**	**6**	**8**
			2	**4**	**8**	**16**
	Small, non-dominant	Not Threatened	5	6	7	8
		Threatened	**7**	**8**	**9**	**10**
			10	**12**	**14**	**16**
			32	**64**	**128**	**256**

Dark grey linear model [x+2]; mid grey linear model [x*2]; light grey.one exponential [2x]

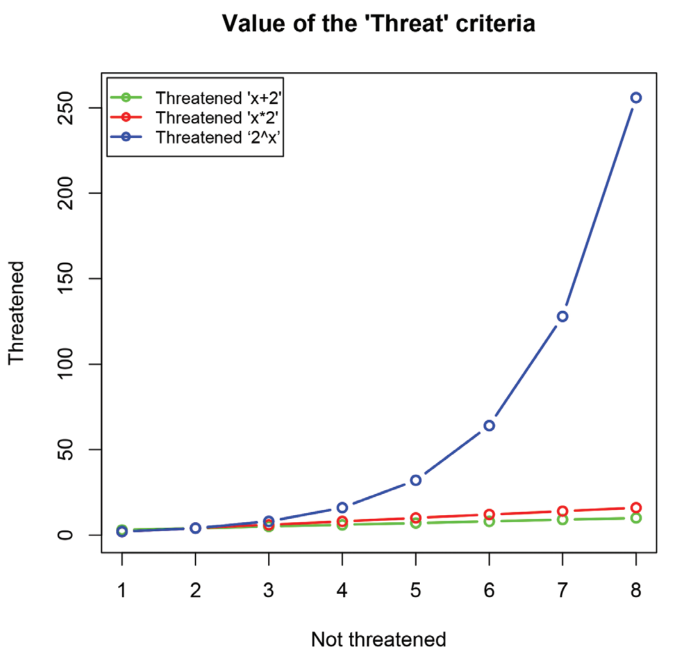

Figure 3. Alternative progressions with various scale models using statistical software R (R Core Team, 2017).

Local population size – *Large, dominant by place*: either by natural means, or as invasive, the population of these species tended to dominate the plant community where it grew, *Small, non-dominant*: population's abundance was always limited by the species biogeographics, or natural history characteristics.

Threat – *Not threatened*: no regulation protection of the species populations (or not evaluated), *Threatened*: at least one regulation (SEMARNAT 2010; IUCN 2016; CITES 2017) acknowledged the species population was under a risk status.

"Framework" species

The "framework" species are characterized by fast growth, developing high population density, rapid adaptation to degraded sites, contributing to weed control and/or providing resources for wildlife (e.g. edible fruit or seed, nectar, roosting, or nesting sites, etc.) (Kerby et al. 2000). Such species also help prevent fire, improve the vegetation structure, attract seed-dispersing animals and accelerate the ecosystem function and recovery of biodiversity (Forest Restoration Research Unit 2000; Blakesley et al. 2002; Goosem and Tucker 2012; Betts 2013; Elliott et al. 2013). This way, the Region of Palmito de Verde (RPV) species complying with at least two of these characteristics have been established as "framework" species.

A table with biological and ecological features of each "priority" and "framework" species is presented (Suppl. material 1: Table S1), providing reproduction features, ideal soil types and reforestation ability. It was built using the Seed Information Database (RBG Kew 2008) and the studies about germination, reforestation, and restoration developed at the south of Sinaloa (Benítez-Pardo et al. 2016; Benítez-Pardo et al. 2017; Benítez-Pardo et al. 2018).

Results

The floristic inventory carried out in the study area found a set of 250 identified species belonging to 200 genera and 74 families. Fabaceae was the most represented with 51 species (21%), followed by Euphorbiaceae (6%) and Malvaceae (5.6%) (Suppl. material 1: Table S2).

A subset of 51 species identified as vulnerable was selected using the Floristic Originality Index (FOI values ≥ 5) and hence were prioritized as concerns for conservation (Table 3).

Additionally, 23 species gathering the most characteristics of "framework" species were selected. Thus, we propose a set of 74 priority species, 51 of concern for conservation and 23 meeting the most characteristics as "framework" species (Table 4, Fig. 4). The most favorable reproduction characteristics and conditions for these 51 'priority' and 23 'framework' species are presented in Suppl. material 1: Table S1.

Table 3. Conservation priorities species ranked by Floristic Originality Index (FOI) value.

Sp#	Taxa	FOI Value
1	*Albizia occidentalis* Brandegee var. *occidentalis*	128
2	*Attalea guacuyule* (Liebm. ex Mart.) Zona	128
3	*Cedrela odorata* L.	64
4	*Sideroxylon capiri* (A.DC.) Pittier	64
5	*Swietenia humilis* Zucc.	64
6	*Sideroxylon persimile* subsp. *subsessiliflorum* (Hemsl.) T.D. Penn.	64
7	*Acanthocereus occidentalis* Britton & Rose	8
8	*Pilosocereus purpusii* (Britton & Rose) Byles & G.D.Rowley	8
9	*Stenocereus alamosensis* (J.M.Coult.) A.C.Gibson & K.E.Horak	8
10	*Diospyros sphaerantha* Standl.	8
11	*Enriquebeltrania disjuncta* De-Nova & V. Sosa	8
12	*Jatropha sympetala* S.F. Blake & Standl.	8
13	*Diodella crassifolia* (Benth.) Borhidi	8
14	*Bourreria superba* I.M.Johnst. var. *superba*	7
15	*Lonchocarpus mutans* M. Sousa	6
16	*Annona glabra* L.	6
17	*Aphananthe monoica* (Hemsl.) J.-F.Leroy	6
18	*Calliandra tergemina* (L.) Benth.	6
19	*Eugenia acapulcensis* Steud.	6
20	*Nymphaea elegans* Hook.	6
21	*Agonandra racemosa* (DC.) Standl.	6
22	*Ziziphus amole* (Sessé & Moc.) M.C. Johnst.	6
23	*Citharexylum affine* D. Don	6
24	*Bursera simaruba* (L.) Sarg.	5
25	*Bursera palmeri* S.Watson	5
26	*Couepia polyandra* (Kunth) Rose	5
27	*Rourea glabra* Kunth	5
28	*Ipomoea arborescens* (Humb. & Bonpl. ex Willd.) G.Don	5
29	*Diospyros salicifolia* Humb. & Bonpl. ex Willd.	5
30	*Erythroxylum havanense* Jacq.	5
31	*Hura polyandra* Baill.	5
32	*Jatropha curcas* L.	5
33	*Coulteria platyloba* (S.Watson) N.Zamora	5
34	*Enterolobium cyclocarpum* (Jacq.) Griseb.	5
35	*Haematoxylum brasiletto* H.Karst.	5
36	*Indigofera suffruticosa* Mill.	5
37	*Lonchocarpus sericeus* subsp. *palmeri* (Rose)M. Sousa	5
38	*Senna fruticosa* (Mill.) H.S.Irwin & Barneby	5
39	*Ceiba pentandra* (L.) Gaertn.	5
40	*Ceiba aesculifolia* (Kunth) Britten & Baker f.	5
41	*Ficus cotinifolia* Kunth	5
42	*Ficus obtusifolia* Kunth	5
43	*Ficus padifolia* Kunth	5
44	*Ficus petiolaris* Kunth subsp. *Petiolaris*	5
45	*Ficus crocata* (Miq.) Miq.	5
46	*Exostema mexicanum* A.Gray	5
47	*Hintonia latiflora* (DC). Bullock	5
48	*Zanthoxylum caribaeum* Lam.	5
49	*Zanthoxylum fagara* (L.) Sarg.	5
50	*Cupania dentata* DC.	5
51	*Thouinidium decandrum* (Bonpl.) Radlk.	5

Table 4. Set of 74 species identified as priority for conservation.

Family	Species
Acanthaceae	*Avicennia germinans* (L.) L.
Annonaceae	*Annona glabra* L.
Arecaceae	*Attalea guacuyule* (Liebm. ex Mart.) Zona
Bignoniaceae	*Crescentia alata* Kunth
	Handroanthus chrysanthus (Jacq.) S.O.Grose
	Handroanthus impetiginosus (Mart. ex DC.) Mattos
Bixaceae	*Cochlospermum vitifolium* (Willd.) Spreng
Boraginaceae	*Bourreria superba* I.M.Johnst. var. *superba*
Burseraceae	*Bursera palmeri* S.Watson
	Bursera simaruba (L). Sarg.
Cactaceae	*Acanthocereus occidentalis* Britton & Rose
	Pilosocereus purpusii (Britton & Rose) Byles & Rose
	Stenocereus alamosensis (J.M.Coult.) A.C.Gibson & K.E.Horak
Cannabaceae	*Aphananthe monoica* (Hemsl.) J.-F.Leroy
Capparaceae	*Crateva tapia* L.
Chrysobalanaceae	*Couepia polyandra* (Kunth) Rose
Combretaceae	*Conocarpus erectus* L.
	Laguncularia racemosa (L.) C.F. Gaertn.
Connaraceae	*Rourea glabra* Kunth
Convolvulaceae	*Ipomoea arborescens* (Humb. & Bonpl. ex Willd.) G.Don
Ebenaceae	*Diospyros salicifolia* Humb. & Bonpl. ex Willd.
	Diospyros sphaerantha Standl.
Erythroxylaceae	*Erythroxylum havanense* Jacq.
Euphorbiaceae	*Enriquebeltrania disjuncta* De-Nova & V. Sosa
	Hura polyandra Baill.
	Jatropha curcas L.
	Jatropha sympetala S.F. Blake & Standl.
Fabaceae	*Albizia occidentalis* Brandegee var. *occidentalis*
	Albizia tomentosa (Micheli) Standl.
	Calliandra tergemina (L.) Benth.
	Coulteria platyloba (S.Watson) N.Zamora
	Enterolobium cyclocarpum (Jacq.) Griseb.
	Gliricidia sepium (Jacq.) Kunth ex Walp.
	Guilandina bonduc L.
	Haematoxylum brasiletto H. Karst.
	Indigofera suffruticosa Mill.
	Leucaena leucocephala (Lam.) de Wit
	Lonchocarpus mutans M. Sousa
	Lonchocarpus sericeus subsp. *palmeri* (Rose) M. Sousa
	Pithecellobium dulce (Roxb.) Benth.
	Prosopis juliflora (Sw.) DC.
	Senna fruticosa (Mill.) H.S.Irwin & Barneby
Lamiaceae	*Vitex mollis* Kunth
Malvaceae	*Ceiba aesculifolia* (Kunth) Britten & Baker f.
	Ceiba pentandra (L.) Gaertn.
	Guazuma ulmifolia Lam.
	Luehea candida (DC.) Mart.
Marantaceae	*Thalia geniculata* L.
Meliaceae	*Cedrela odorata* L.
	Swietenia humilis Zucc.
Moraceae	*Ficus cotinifolia* Kunth
	Ficus crocata (Miq.) Miq.
	Ficus obtusifolia Kunth
	Ficus padifolia Kunth
	Ficus petiolaris Kunth subsp. *Petiolaris*
Myrtaceae	*Eugenia acapulcensis* Steud.
Nymphaeaceae	*Nymphaea elegans* Hook.
Opiliaceae	*Agonandra racemosa* (DC.) Standl.
Polygonaceae	*Coccoloba barbadensis* Jacq.
Rhamnaceae	*Ziziphus amole* (Sessé & Moc.) M.C. Johnst.

Family	Species
Rhizophoraceae	*Rhizophora mangle* L.
Rubiaceae	*Diodella crassifolia* (Benth.) Borhidi
	Exostema mexicanum A.Gray
	Hintonia latiflora (DC.) Bullock
Rutaceae	*Zanthoxylum caribaeum* Lam.
	Zanthoxylum fagara (L.) Sarg.
Salicaceae	*Casearia nitida* Jacq.
	Salix nigra Marshall
Sapindaceae	*Cupania dentata* DC.
	Sapindus saponaria L.
	Thouinidium decandrum (Bonpl.) Radlk.
Sapotaceae	*Sideroxylon capiri* (A.DC.) Pittier
	Sideroxylon persimile subsp. *subsessiliflorum* (Hemsl.) T.D. Penn.
Verbenaceae	*Citharexylum affine* D. Don

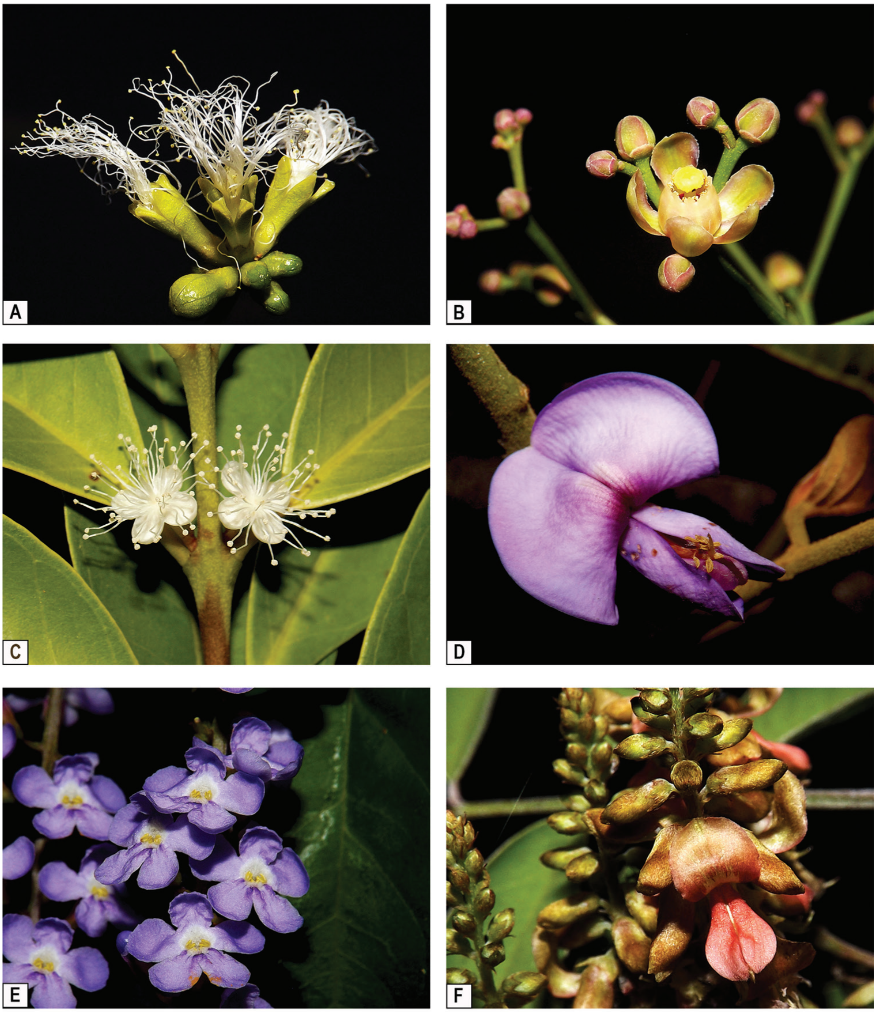

Figure 4. Examples of several priority species in the flora of south Sinaloa, Mexico. **A** *Albizia occidentalis* Brandegee var. *occidentalis*, **B** *Swietenia humilis* Zucc., **C** *Eugenia acapulcensis* Steud., **D** *Lonchocarpus sericeus* subsp. *palmeri* (Rose) M. Sousa, **E** *Citharexylum affine* D. Don, **F** *Indigofera suffruticosa* Mill.

Discussion

The floristic inventory shows that the Region of Palmito de Verde follows a pattern similar to others sites in Mexico, in relation to the more abundant families. The family Fabaceae usually is the most common in dry and semideciduous forest in the country (Lott et al. 1987; Gentry 1995; Zamora-Crescencio et al. 2008; Rocha-Loredo et al. 2010; Gutiérrez-Báez et al. 2011; Gutiérrez-Báez et al. 2012; León-de la Luz et al. 2012; Dzib-Castillo et al. 2014; Méndez-Toribio et al. 2014; Bravo-Bolaños et al. 2016; Gutiérrez-Báez et al. 2016; Gutiérrez-Báez et al. 2017; Zamora-Crescencio et al. 2017). In relation to Mangroves, this information only reinforces what has already been published by Blanco y-Correa Magallanes (2011). The set of information obtained in this study contributes to the completion of the botanic data of Sinaloa National Marshes and surrounding areas.

A database about the species richness in the region is very scarce, e.g. CONANP (2008) recorded 35 species, by the RPV; CONANP (2013) recorded 51 species and Valdez-Hernández (2002) recorded 82 species for the Nayarit National Marshes, an adjacent region. Thus, the outcomes of this investigation seek to encourage the researches focused on the knowledge and conservation of flora in the Region Priority for Conservation National Marshes.

The method developed during the project to determine species floristic originality enabled the determination of a set of 51 species of concern for conservation over which multiplication capacity (sexual or vegetative) could be focused on for forest restoration aims. An additional set of 23 species meeting the most characteristics as "framework" species may be considered since they can withstand harsh conditions in areas of open vegetation (Betts 2013) in the RPV.

Some "framework" species, such as *Leucaena leucocephala* (Lam.) de Wit (Fabaceae), *Prosopis juliflora* (Sw.) D.C. (Fabaceae), *Vitex mollis* Kunth (Lamiaceae), *Guazuma ulmifolia* Lam. (Malvaceae), *Thalia geniculata* L. (Marantaceae), *Casearia nitida* Jacq. (Salicaceae) *Pithecellobium dulce* (Roxb.) Benth. (Fabaceae), *Luehea candida* (DC.) Mart. (Malvaceae) and *Salix nigra* Marshall (Salicaceae) , among others, can be considered as common species. Nevertheless, their use for restoration may accelerate natural regeneration in restoring a multi-layer forest canopy and favor the recovery of nutrient cycles on disturbed sites (Blakesley et al. 2002; Elliott et al. 2003).

While some recommend no more than 10% of the species for conservation topic (Elliott et al. 2013), we consider that the currently available information allows us to lead conservation, reproduction and restoration programs with this number of selected priority species (Table 4) representing 30% of the area's identified flora.

However, to be applied, this methodology must first address three issues and limitations. This scheme contributes to the prioritization of species from a conservation biology point of view. It is therefore useful in programs aimed at rehabilitating the structure and functioning of plant associations in a given region (Mudappa and Raman 2010; Peel 2010; Goosem and Tucker 2012; Neidel et al. 2012; Elliott et al. 2013). The features of a species determined by this method may be subject to change through time and therefore it should be updated on a regular basis. The characteristics found by this method are directly influenced by the ecological niche of the different species to be evaluated, so it must be considered that the generated information is local. It hence cannot be extrapolated to a larger scale because environmental gradients affect the patterns of flowering, the number of viable seeds, germination, abundance and other factors (Godsoe 2010; Chase 2011; Cox et al. 2016).

Conclusion

In the current study, the modified Floristic Originality Index model developed during this project has identified a set of most vulnerable and rare species to select "priority" and "framework" tree species able to restore forests structure and biodiversity as well as ecosystem functions. Fifty-one conservation "priority" and 23 "framework" species were selected herein, completing available data for production and reforestation works in the Region of Palmito de Verde. Some guidelines to obtain seeds, seedlings and cuttings for wildlife management and restoration were also proposed.

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Supplementary material 1

Tables S1, S2

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Data type: species data

Explanation note: **Table S1.** Priority and framework species for the Region of Palmito de Verde, state of Sinaloa, Mexico, with reproductive characteristics after RBG Kew (2008) and Benítez-Pardo et al. (2016, 2017, 2018). **Table S2.** Inventory Floristic of the Region of Palmito de Verde, state of Sinaloa, Mexico.

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