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Local knowledge helps select species for forest restoration in a tropical dry forest of central Veracruz, Mexico

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Abstract Species for restoration forestry on degraded lands in the tropics are often restricted to a few well-known exotic timber species. This selection frequently leads to failed projects, as local people expect trees to cover a number of uses, not only timber. We studied local knowledge of the usefulness, scarcity and importance for wildlife of native tree species in central Veracruz, Mexico, a region with mainly secondary vegetation and remnants of tropical dry forest. Data were obtained from several workshops, in depth interviews of 40 key informants, field walks with informants, and botanical collections. Analysis included indices for cultural importance, scarcity and wildlife relevance. We documented 76 species in one or more of the categories, from primary, secondary, agroforestry and riparian habitats. Fabaceae was the most important family. All of the species were useful for humans, mainly for rural construction, food, fence posts and fuel. Two-thirds of the species were considered scarce though they were not necessarily rare—some were highly useful, overexploited species with populations insufficient for demand; this category included five of the ten most important species culturally. Also, two-thirds of the tree taxa were considered important for wildlife, especially species of Moraceae. The study shows that the local population is highly aware of the varying functions of trees in the landscape. However, few of the important species are available from regional nurseries. We propose a number of species for restoration forestry, agroforestry systems and enrichment plantings that would be valued by landowners.

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Introduction

Forestry plantations on degraded or deforested land are a strategy to recover biodiversity and soil productivity in agricultural and ranching landscapes; they act as a facilitator for forestry succession. Trees can be planted in lines, groups or as a component of agroforestry and silvopastoral systems (Lamb et al. 2005; Montagnini 2001). Generally, the use of native species is preferable, because they are already adapted to the environment, and are not a risk as an invasive species. Also, well-managed plantations of native trees can play an important social and economic role, by providing numerous goods known to and useful for the local population, as well as shelter and food for wildlife (Montagnini 2005). Mixed plantations with native species may also offer some ecological and economic advantages (Piotto et al. 2004a), be more sustainable and less prone to catastrophic damage by pests and diseases.

Selecting appropriate species for any kind of forestry plantation involves two basic principles: an adequate adaptation to the environmental conditions and compliance with the aims of production and/or conservation. This decision is a key factor for success, as forestry plantations absorb a great deal of human and financial resources for a long period of time (Evans 1992). Also, it is important to consider the "founder effect" of the planted species since they will influence the direction of ecological succession (Lamb and Gilmour 2003; the founder effect refers to the effect of the genetic composition of small initial populations on the characteristics of resulting larger populations). A bad decision in species selection that does not take into account landowner interests may also discourage tree planting among the farmers (Cervantes et al. 1996; Mekoya et al. 2008). In Mexico, after government programs have promoted exotic species for six decades, since the 1990s the focus of reforestation has partly changed to promoting the use of native species (Carabias et al. 2007).

Decisions on species selection are usually made by technicians in charge of reforestation and restoration programs, based on published information or their own experience. This practice, however, ignores local knowledge and the needs of local communities, and often leads to failures because of the lack of interest of the local population (Mekoya et al. 2008).

Various authors have proposed that traditional resource management systems and the ecological knowledge of local people can be integrated into strategies and methods of rehabilitation and conservation of tropical forests (Diemont et al. 2006; Levy 2000; Levy and Golicher 2004; Monroy-Ortiz et al. 2009). A participative approach would improve adoption of multipurpose species in agroforestry and reforestation (Mekoya et al. 2008; Montagnini et al. 2008).

Several studies from the Mesoamerican dry tropics have shown that local farmers often prefer native species for plantations to exotics, for economic or environmental reasons (Garen et al. 2009; Piotto et al. 2004b). Analysis of local knowledge of vegetation dynamics and species preference helps to identify priority species (Lykke et al. 2004). In the Philippines, ethnobotanical studies identified species with social and ecological importance, in order to integrate them in agroforestry systems that are analogous to natural forests (Langenberger et al. 2009).

The tropical dry or deciduous forest is a vegetation type known from semiarid to subhumid tropical regions with a dry season of 5–8 months (Mooney et al. 1995; Murphy and Lugo 1986). In Mexico, it is called "selva baja caducifolia" by Miranda and Hernández-X (1963) and "bosque tropical caducifolio" by Rzedowski (1978). The area potentially covered by this type of vegetation in Mexico is approximately 270,000 km^2 (14% of the land cover). However, at the beginning of the 1990s just 27% remained intact, 50% was disturbed to different degrees and 23% had been converted to agricultural and pastureland (Trejo and Dirzo 2000).

Deforestation and land-use change in this kind of forest lead to the loss of valuable biological resources which are the base for survival of human populations in marginal areas (Bye 1995; Challenger 1998). Also, the loss of forest cover reduces resources to face a reduction in rainfall and increases in temperature predicted as a consequence of global climate change (Miles et al. 2006; Villers-Ruiz and Trejo-Vázquez 1997).

The tropical dry forest is not well-represented along the relatively humid Gulf coast of Mexico, where Veracruz is located (Rzedowski 1978). Despite its relative rarity, it is remarkable for its structural and floristic diversity, its level of endemisms and number of endangered species (Castillo-Campos 2003; Castillo-Campos et al. 2005; Medina and Castillo-Campos 1993; Williams-Linera and Lorea 2009; Zacarías 2007). It is a priority area for conservation as part of the migration corridor of birds of prey between North and Central America (Arriaga et al. 2000), and one of the richest areas in reptiles (Flores-Villela 1993). In the center of Veracruz, like in other areas of tropical dry forest, this type of vegetation has been fragmented and severely degraded by human activities, and has been replaced by secondary communities and shrubland (Rzedowski 1978).

In the region of Paso de Ovejas, Veracruz, governmental institutions have promoted both commercial plantations and restoration forestry but they have focused on commercial timber species, such as *Cedrela odorata*, *Tabebuia rosea*, *Tabebuia donnell-smithii* Rose, *Gmelina arborea* Roxb. ex Sm. and *Tectona grandis* L.f. (complete scientific names of the species in the study area can be found in the tables). The first two are native and the latter three are introduced. These species are preferred by government projects because seed is easily available and their management well-known.

The use of these few species contrasts with the floristic richness found in both the remaining fragments of forest (Medina and Castillo-Campos 1993; Williams-Linera and Lorea 2009; Zacarías 2007), the secondary vegetation (Hernández 2008) and in the agro-silvopastoral and silvopastoral systems of the region (Bautista 2009). Also, locally known trees provide numerous benefits to the local population (Couttolenc-Brenis et al. 2005; Leyva 2006), apart from timber. Integrating more native species in reforestation programs is an opportunity to promote the biodiversity conservation of woody species, but also to benefit local communities.

This study is part of an international collaborative research project, ReForLan, focusing on the restoration of dryland forest landscapes for biodiversity conservation and rural development in Latin America (Newton 2008). Some previous work on restoration forestry has been carried out in Veracruz (e.g., in cloud forest, Pedraza and Williams-Linera 2003; Alvarez-Aquino et al. 2004), and only recently in dry forests, and as part of the ReForLan project (Williams-Linera and Alvarez-Aquino 2010). Other workers experimented with species of the humid tropical forests. A very useful synthesis of the knowledge on native Mesoamerican forestry species, including dry forests, is the manual by Cordero and Boshier (2003).

Our general objective was to select woody species for tropical dry forest restoration, based on local knowledge. The selection should address both the economic interests of local communities (useful species), and conservation objectives (scarce species and those important for wildlife), according to local peoples' perceptions. Participatory surveys determined local patterns of use and the social, cultural and economic value of dry forest resources to local communities, and identified priority forest tree species for restoration. This study employs simple methods that can be used to incorporate local knowledge in the process of species selection for restoration forestry.

Materials and methods

Study area

The study area is located in the center of Veracruz State, Mexico, in six rural communities (Table 1) belonging to the municipalities of Paso de Ovejas and Comapa (19°10′–19°18′ N, 96°25′–96°40′ W, altitude 40 m near Mata Mateo to 480 m near Dos Caminos, Fig. 1). The region is hilly and is crossed from SW to NE by the Paso de Ovejas river canyon.

The dominant vegetation used to be tropical dry forest ("selva baja caducifolia") on the hills, and tropical semi-evergreen forest ("selva mediana subperennifolia") in the canyons and along rivers (Medina and Castillo-Campos 1993). Today, the region is covered mainly by tropical pastures, agricultural lands and secondary vegetation. The climate is warm and sub-humid with a long dry season of 7–8 months and a summer with rainfall between June and October. Average annual precipitation is 973 mm and evaporation 1,466 mm; annual average temperature is 24.8°C with an average minimum and maximum of 18.7 and 30.7°C, respectively (CNA 2008).

The main economic activity in the communities of the study area is agriculture and cattle ranching. The livestock farmers occupy almost 80% of the land, with about one to 10 ha per ranch; the land rights are of the "ejido" type, a kind of cooperative with usufruct rights (Linea 2008). The main crops are maize, beans and papaya; broom sorghum (*Sorghum bicolor* (L.) Moench) is also grown, as are chillis, mangos and tamarinds (Gallardo-López et al. 2002). The cattle are double-purpose hybrids (*Bos taurus* × *Bos indicus*), held on grasslands of introduced African grasses. Guinea, *Panicum maximum* Jacq., and jaragua, *Hyparrhenia rufa* (Nees) Stapf, are dominant (Bautista 2009). In general, the herds have one to 10 heads (Línea 2008). Ranching and farming are commonly

Table 1 The communities where five short workshops and two focus group meetings were conducted, number of inhabitants and number of workshop/focus group participants

Community	Municipality	Inhabitants*	Participants in workshops		
			Females	Males	Sum
A. Short workshops					
Angostillo	Paso de Ovejas	689	2	17	19
Dos Caminos	Comapa	118	4	7	11
Mata Mateo	Paso de Ovejas	124	12	12	24
Rancho Nuevo	Paso de Ovejas	364	1	21	22
Xocotitla	Paso de Ovejas	243	0	19	19
B. Workshop with focus group					
El Limón (2 meetings)	Paso de Ovejas	300	2	5	7

* *Source*: INEGI (2009)

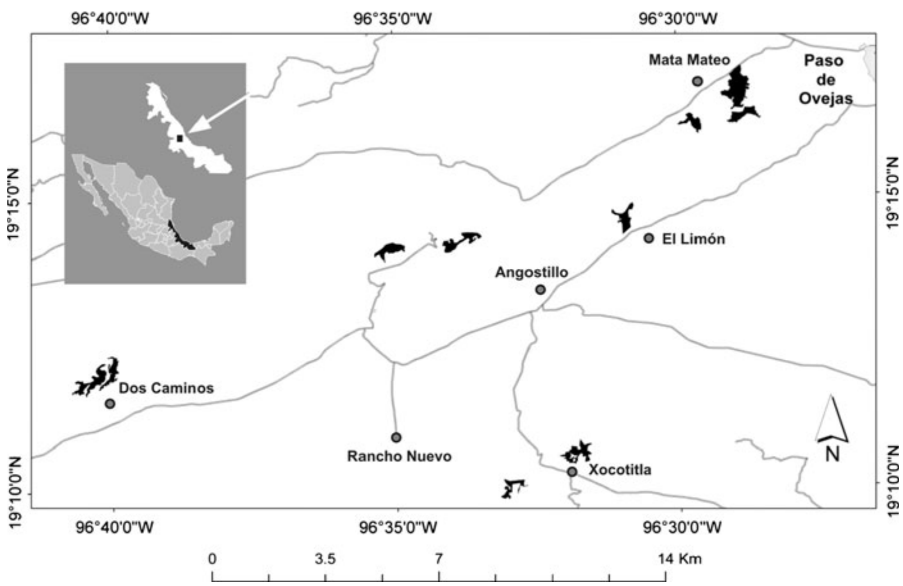

Fig. 1 Map showing the location of the study area in central Veracruz, Mexico. Short workshops were conducted in Mata Mateo, Angostillo, Dos Caminos, Rancho Nuevo and Xocotitla; the two focus group meetings were conducted in El Limon. Forest fragments studied by Williams-Linera and Lorea (2009) in the area are represented as *dark polygons*

integrated, and include agrosilvopastoral (maize, trees and cattle) and silvopastoril (trees, grass and cattle) systems (Bautista 2009).

Short workshops in the rural communities and interviews

The rural communities were selected for being located near forest fragments, where farmers would use forest resources and have a better knowledge of trees (Leyva 2006). In these villages, many farmers have established forestry plantings, mainly linear ones on the edges of pastures, taking advantage of government programs. These communities could play a major role in the management and conservation of remainder forests; local knowledge and interest are important factors for creating viable biological corridors (Bennett 2003). However, they have not been a particular focus of government interventions or programs.

First, permission for the study was obtained from local authorities. The work with the communities initiated with short workshops. Local authorities invited ejido members and the general public to a meeting, where a brief project presentation was followed by an explanation of the importance of native woody species. The participants were queried on their knowledge of woody species (trees and shrubs) in three categories: (1) Useful ("útil"), including all of the local uses, (2) Scarce ("escaso"), species that were perceived to have a low abundance,

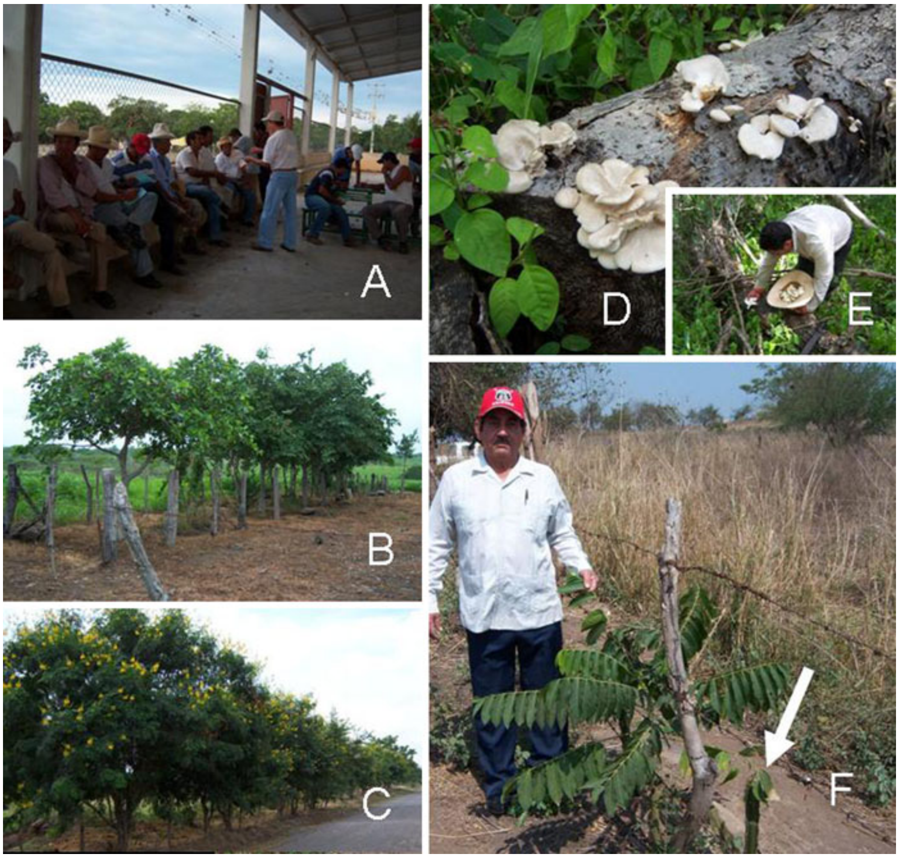

Fig. 2 Field work and agroforestry practices. **a** Workshop in Xocotitla, Veracruz. **b** Young trees of various species of *Ficus*, protected by a fence and irrigated during the dry season. *Ficus* is planted as a shade tree for cattle. **c** Naturally regenerating *Caesalpinia cacalaco*, transplanted to form a living fence. **d** *Pleurotus* mushrooms on a felled *Ipomoea wolcottiana* ("patancán") trunk. **e** Mushroom collection. **f** A recently transplanted cedro (*Cedrela odorata*) from a nursery, protected against cattle by an also transplanted cactus ("cruceta") (*arrow*)

and (3) Valuable for wildlife (fauna) ("valioso para animales silvestres"), as a source of food or shelter.

We conducted five workshops with a total of 95 participants (Table 1; Fig. 2), 80% male and 20% female. This gender imbalance is due to the fact that mainly men go to meetings, but also work in the pastures and forest remnants. Ages ranged from 12 to 84 years; most (57%) were men over 39 years of age. The key informants (see below), 36 men and 4 women, were all older than 39.

The workshops were conducted as an open group interview (Geilfus 1998). Three questions were asked in writing: which native trees are useful? Which native trees are scarce? Which native trees are beneficial for wildlife? Cards of three different colors (one for each question) were handed out, and participants annotated their name and age, as well as the local names of all trees in the category. Open discussion was allowed. People who could not write indicated their answers to a research assistant. The individuals who listed most names or novelties were considered key informants, and their help was solicited for field walks, in order to find and collect the trees and to supplement the preliminary lists.

About three-quarters of the key informants were identified during the workshops; a few other key informants were found by recommendations or through encounters in the field, for a total of 40 interviews and 35 field walks between May 2007 and November 2008.

Key informants were questioned more systematically with semistructured interviews on the use and management of the woody plants, and wild animals associated with them. Additional information on the use of species was gathered from two focus group meetings organized together with the anthropologist María Elena Ramos Vásquez at the El Limón community.

Field walks and collection of vouchers

Botanical vouchers were collected based on the common names obtained in the workshops and additional indications by the key informants, during walks in the field (agricultural and pasturelands, secondary vegetation and forest fragments). The trees were classified as typical of mature forests ("matas"), secondary forests ("acahuales"), gallery forests and agroforestry systems by the informants; these classifications were verified by direct observation. Also, photographs were taken of the trees, relevant parts, management practices and products. The species were identified by the first author at the XAL herbarium, with specialized literature and reference to the herbarium; the first set has been deposited at XAL and the second set at CHAPA. The genera were assigned to families based on the taxonomy of the Angiosperm Phylogeny Group (2003).

Information analysis

The information was systematized in Microsoft Excel spread sheets. Cacti and agaves were included in the analysis, and exotic fruit trees cultivated exclusively in home gardens were excluded, though several of them were mentioned in the workshops. The main categories were those of the interviews: species that are useful, scarce, or important for wildlife.

Species richness

The efficiency of data collection in the workshops was estimated with a non-parametric estimator for expected species accumulation curves (Chao 1) using the EstimateS versión 7.5 software (Colwell 2005), with the pre-established options of the program. This estimator has been evaluated repeatedly for ecological purposes and proved to be relatively reliable (Chao 1984; Colwell and Coddington 1994; and in our region López-Gómez and Williams-Linera 2006). Also, the software permitted comparison of the fit of the data with various estimators and Chao1 showed the best fit. Ecological concepts and methods are often useful for understanding human–environment interactions (Begossi 1996).The Chao 1 estimates the total number of existing species, based on data obtained from vegetation surveys (or, in our case, interviews), using abundance data and the number of rare species in the sample.

$$S_{Chao1} = S_{obs} + F_1^2/2F_2$$

where S is the species number in a sample, F_1 is the species number mentioned once (*singletons*) and F_2 is the species number mentioned twice (*doubletons*) (Colwell and Coddington 1994).

Sampling effort in this analysis was the number of workshops; they were plotted on the abscissa of the species accumulation curve.

Complementarity (the opposite of similarity; Colwell and Coddington 1994) was calculated in order to evaluate dissimilarity between workshops. The complementarity varies from 0% when both lists are identical to 100% when the lists are completely different. We used the following formula (Colwell and Coddington 1994):

$$C = \left[\left(S_j + S_k - 2V_{jk}\right)/\left(S_j + S_k - V_{jk}\right)\right] \times 100$$

where S_j and S_k are the number of species at the workshop j and k, and V_{jk} is the number of species in common between both events.

Useful species

A number of indices have been proposed to evaluate the cultural importance or significance of species; they are based mainly on characteristics of their use (Lucena et al. 2007; Pieroni 2001; Turner 1988) and often incorporate an evaluation by the investigator. Albuquerque et al. (2009) propose an index to prioritize species relevant for conservation at a local level, based on uses, frequency in home gardens and relative density in forests; the authors suggest this index is useful for selecting species for reforestation or cultivation in overexploited areas.

However, we found that an index modified from the index proposed by Figueroa (2000) and López (2008) was the best fit for our purposes and data, particularly the quantitative data from interviews. This index was calculated for each species. It reflects the relative contribution (as percentage) of the following variables: number of mentions (NM), for all the uses and in all the workshops; frequency of mention in the region (FR), for the number of workshops in which it was mentioned; number of uses (NU) and use value (UV). The use-related factors were based on the detailed information obtained from the key informants; the use value was assigned by the first author on a scale of three—one (low), two (middle) and three (high) based on these interviews and observations.

$$\mathrm{CII} = (\mathrm{NM} + \mathrm{FR} + \mathrm{NU} + \mathrm{UV})/4$$

Scarce species

The Scarcity Perception Index (SPI) was also calculated for each species. It integrated the following variables: number of mentions (NM) in the category of scarce and frequency of mention at regional level (FR) for the number of workshops where it was mentioned as scarce.

$$\mathrm{SPI} = (\mathrm{NM} + \mathrm{FR})/2$$

Species important for wildlife

In the same way, the Wildlife Importance Perception Index (WIPI) reflects local knowledge on the role of woody plants for wild animals. This index used the following variables: number of mentions (NM), for all species of wild fauna and in all the workshops; frequency of mentions in the region (FR), which consists of the number of workshops in which it was mentioned; number of species of fauna that use the resource (NF) and finally a usefulness value (UV) with a scale of two: one if it is used as shelter or food and two if it is used for both.

$$\mathrm{WIPI} = (\mathrm{NM} + \mathrm{FR} + \mathrm{NF} + \mathrm{UV})/4$$

As each of these indices is expressed as percentage, the result for all the species for each index will add up to 100.

Results

Species mentioned in workshops

Participants in the short workshops (Fig. 2) named between 34 and 47 native species in each event, for a total of 75 native species for the categories useful, scarce and important for wildlife. The species belonged to 29 botanical families (Appendix Table 4). Fabaceae had most species (18), followed by Bignoniaceae and Malvaceae with 5 each. Exotic species were also mentioned: 13 fruit trees, two ornamentals and one timber tree. These were not included in the analysis, as this study aimed to evaluate native species only.

The species accumulation curve of the short workshops did not reach a definite asymptote, but the estimator Chao 1 indicated that the species inventory was 97.5% complete, so only two species would not have been registered. Also, the curve of the species mentioned only once (singletons) declined and crossed the curve of the species mentioned twice (doubletons), suggesting that the inventory was nearly complete (Fig. 3).

The information provided in the workshops had a complementarity of 48% on average; not surprisingly, the results of places close to each other had less complementarity and more species in common (Rancho Nuevo and Xocotitla: 43.1%) than those that were

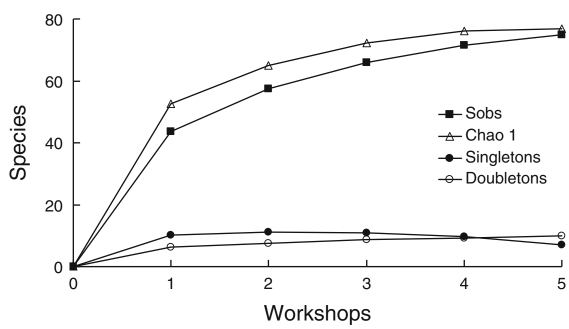

Fig. 3 Accumulation curve of species mentioned by the informants during the short workshops in central Veracruz, Mexico. Sobs are the species number mentioned by workshop. Chao 1 is an abundance-based estimator of species richness. Singletons are the species number mentioned once and doubletons are the species number mentioned twice

Table 2 Complementarity (%) of the native woody species mentioned in the five short workshops in the municipalities of Paso de Ovejas and Comapa, Veracruz, Mexico

Short workshop site	Rancho Nuevo	Mata Mateo	Xocotitla	Dos Caminos
Angostillo	45.0	45.0	50.0	51.6
Rancho Nuevo		46.7	43.1	45.8
Mata Mateo			49.1	53.2
Xocotitla				50.9

more distant (Dos Caminos and Mata Mateo: 53.2%) (Table 2).

Only one species was added during the walks in the field with informants (*Annona purpurea*), which was useful, scarce and important for wildlife. So, the final inventory consisted of 76 native species—68 trees and 8 shrubs. Of these, 52 species were typical of mature forests, 27 of secondary forests, 44 of agroforestry systems and 3 of gallery (riparian) vegetation (Appendix Table 4).

Useful species

All of the 76 species included in the inventory were useful (Appendix Table 4). Only 54 were mentioned as such in the workshops, but the interviews with key informants complemented that information. Twelve use categories were recognized, with rural construction being the most important one with 30 species, followed by edible/food (26), fence posts (22), fuel (both firewood and charcoal) (17), medicinal (17), living fence (15), ornamental (15), forage (13), agricultural tool manufacture (for example tool handles, hooks; 10), shade tree for livestock (9), timber (8) and handicrafts (for example brooms, hammocks, receptacles; 5). Two-thirds of the species (71%) had more than one use. Workshop participants agreed that the most important uses in terms of quantity were fuel and fence posts, though we have no detailed data on this.

Table 3 Values of the indices for usefulness, scarcity and importance for wildlife (see text), for the ten most important species of each category

Species	Useful species					Scarce species			Species important for wildlife				
	NM	FR	NU	UV	CII	NM	FR	SPI	NM	FR	NF	UV	WIPI
Acacia cochliacantha	**4.4**	**3.4**	**1.6**	**2.3**	**2.9**	**3.4**	**2.6**	**3.0**	0.6	2.1	1.1	1.0	1.2
Brosimum alicastrum	0.4	0.7	1.6	1.6	1.1	1.2	2.6	1.9	**4.4**	**3.1**	**4.5**	**4.9**	**4.2**
Byrsonima crassifolia	2.1	1.3	1.1	1.0	1.4	1.8	1.7	1.8	**2.6**	**4.2**	**2.2**	**2.0**	**2.8**
Caesalpinia cacalaco	**4.9**	**3.4**	**1.6**	**2.3**	**3.0**	**3.4**	**3.5**	**3.4**	0.0	0.0	0.0	0.0	0.0
Calyptranthes schiedeana	1.5	3.4	2.1	1.9	2.2	2.2	1.7	1.9	**11.7**	**5.2**	**6.7**	**6.9**	**7.6**
Cedrela odorata	**6.4**	**3.4**	**1.6**	**2.6**	**3.5**	**2.2**	**3.5**	**2.8**	0.3	1.0	2.2	2.0	1.4
Chloroleucon mangense	**8.3**	**3.4**	**3.2**	**3.9**	**4.7**	**6.8**	**3.5**	**5.1**	0.3	1.0	1.1	1.0	0.9
Diphysa carthagenensis	**6.8**	**3.4**	**2.1**	**2.6**	**3.7**	**10.8**	**4.3**	**7.6**	0.0	0.0	0.0	0.0	0.0
Ehretia tinifolia	2.5	2.7	1.1	1.3	1.9	1.5	1.7	1.6	**7.6**	**4.2**	**2.2**	**2.9**	**4.2**
Enterolobium cyclocarpum	3.0	3.4	2.1	2.9	2.8	**3.1**	**2.6**	**2.8**	**2.9**	**4.2**	**3.4**	**3.9**	**3.6**
Ficus cotinifolia	0.8	2.0	1.6	1.6	1.5	2.2	2.6	2.4	**15.5**	**5.2**	**5.6**	**6.9**	**8.3**
Gliricidia sepium	**3.2**	**3.4**	**2.7**	**2.6**	**2.9**	0.9	1.7	1.3	0.3	1.0	1.1	1.0	0.9
Guazuma ulmifolia	1.7	2.7	2.1	3.2	2.4	0.3	0.9	0.6	**7.6**	**5.2**	**3.4**	**2.9**	**4.8**
Leucaena lanceolata	**5.1**	**3.4**	**3.2**	**3.9**	**3.9**	2.8	1.7	2.3	0.9	2.1	1.1	1.0	1.3
Lysiloma acapulcense	**8.5**	**3.4**	**2.1**	**3.5**	**4.4**	**8.6**	**3.5**	**6.0**	0.6	2.1	2.2	2.9	2.0
Lysiloma divaricatum	1.7	3.4	1.6	1.9	2.1	**3.1**	**3.5**	**3.3**	0.3	1.0	2.2	2.9	1.6
Maclura tinctoria	**3.8**	**3.4**	**2.7**	**3.2**	**3.3**	0.6	0.9	0.7	**5.0**	**4.2**	**4.5**	**5.9**	**4.9**
Manilkara zapota	0.8	2.0	1.1	1.3	1.3	1.2	1.7	1.5	**5.6**	**4.2**	**3.4**	**2.9**	**4.0**
Spondias purpurea	2.3	2.7	1.1	1.3	1.8	0.0	0.0	0.0	**7.9**	**4.2**	**3.4**	**2.9**	**4.6**
Tabebuia chrysantha	**5.1**	**3.4**	**3.2**	**3.5**	**3.8**	1.8	2.6	2.2	0.3	1.0	2.2	2.0	1.4
Tabebuia rosea	1.5	2.0	2.7	3.5	2.4	**4.0**	**3.5**	**3.7**	0.3	1.0	2.2	2.0	1.4
Wimmeria pubescens	0.6	1.3	1.1	0.6	0.9	**4.9**	**1.7**	**3.3**	0.3	1.0	1.1	1.0	0.9
54 other species	24.6	38.9	56.9	47.5	42.0	33.2	47.8	40.5	25.1	42.7	43.8	41.2	38.2

Columns are number of mentions (NM), frequency of mention in the region (FR), number of uses (NU), use value (UV), number of species of fauna that use the resource (NF), Cultural Importance Index (CII), Scarcity Perception Index (SPI) and Wildlife Importance Perception Index (WIPI). All values are expressed in percentages. Bold numbers indicate the 10 most important species of each category

The species with most uses—six—were *Chloroleucon mangense*, *Leucaena lanceolata* and *Tabebuia chrysantha*; the first two also had both the highest use values (UV; Table 3) and the first and third place in cultural importance (CII, Table 3); *Lysiloma acapulcense*, an important fence post species, was in second place of cultural importance. The ten species with the highest Cultural Importance Index value concentrated 36% of this index; seven of these were legumes from secondary forests (acahuales). The primary use of most was as fuel, with the following species being preferred: *Acacia cochliacantha*, *Acacia pennatula*, *Diphysa carthagenensis* and *Leucaena lanceolata.*

Other relevant uses influencing the Cultural Importance Index were those related to ranching. Trees with abundant heartwood were appreciated because their wood can be used outdoors without additional treatment, for example as fenceposts and for corrals. The preferred species were *Chloroleucon mangense, Lysiloma acapulcense, Diphysa carthagenensis, Maclura tinctorea* and *Tabebuia chrysantha*. Forage trees were important mainly in the dry season, when grass production decreases drastically. Cattle will eat young leaves of *Leucaena lanceolata*, *Gliricidia sepium*, *Guazuma ulmifolia* and fruit of *Guazuma ulmifolia, Acacia cochliacantha*, *Acacia pennatula*, *Chloroleucon mangense*, *Caesalpinia cacalaco* and *Senna atomaria*. Farmers valued the contribution of these species to the maintenance of their livestock, though they also knew that they were dispersed by manure, and seedlings had to be cut if numbers were too high. The main shade trees for livestock were *Lysiloma acapulcense*, *Ehretia tinifolia, Maclura tinctorea* and *Ficus cotinifolia*; the first one was preferred because it has a lighter shade that allows grass to grow underneath.

Properties usually had barbed wire fences with wooden posts. Live trees growing naturally on the property lines were integrated as posts and formed live fences. There was little direct planting of stakes, as they will often die in dry years (mainly *Bursera simaruba* and *Bursera cinerea*). Some farmers found that plants grown from seedlings of *Caesalpinia cacalaco* and *Chloroleucon mangense* were better for establishing live fences. Government organizations promoted planting of *Gliciridia sepium* in contour lines in the 1990s for soil erosion control in maize. However, farmers now said that they grow too fast, produce very numerous seeds and have become weeds that are difficult to eradicate; seedlings are often not killed by cutting or even plowing.

Timber production on property borders and divisions is a relatively new practice. Farmers preferred these to compact plantations. Various government programs from the 1980s onward had provided free seedlings of exotic (*Tectona grandis* L.f., *Gmelina arborea* Roxb. ex Sm. and *Tabebuia donnell-smithii* Rose) and native (*Tabebuia rosea* and *Cedrela odorata*) timber species. *Cedrela* was the most popular tree, because it produces the most valuable timber of the region. However, farmers did not yet have sufficient experience to space and prune these trees properly. *Cedrela* may have shoot borer (*Hypsipyla gradella* (Zeller) infestations, but they are usually less severe in mixed cultivation (Newton et al. 1993; Rao et al. 2000).

One-third of the useful species (26) produced food, for example the flowers of *Erythrina*, *Yucca* and *Gliciridia sepium,* the stems of *Nopalea*, the seeds of *Leucaena lanceolata* and *Leucaena leucocephala;* there were 20 fruit species (Appendix Table 4). Edible species were often fomented and protected, or transplanted to home gardens and live fences, where harvesting is easier.

Two types of edible mushrooms grew on the dead wood of *Ipomoea wolcottiana* ("patancán") in the rainy season; they were not identified, but one was probably a *Pleurotus*, known as "hongo de oreja"; the other one was called "hongo de patancán" (Fig. 2d, e). Trees were deliberately felled in the dry season to provide substrate for these mushrooms. However, farmers also believed that live *Ipomoea* trees will attract lightening that can be fatal to people and livestock.

Scarce species

Two-thirds of the useful species (68% of 76 species) were considered scarce by farmers, in the workshops, the key informant interviews and field surveys. *Diphysa carthagenensis, Lysiloma acapulcense, Chloroleucon mangense, Caesalpinia cacalaco* and *Cedrela odorata* were considered scarcest (Table 3). The ten species with the highest Scarcity Perception Index (SPI) concentrated 41.2% of this index; seven were legumes and five were among the ten species with the highest Cultural Importance Index.

Farmers said that *Diphysa carthagenensis* has been overexploited for firewood and fenceposts. Even though the species resprouts from cut stems, there were hardly any trees with sufficient wood for exploitation, only mats of thin stems. *Lysiloma acapulcense* was also overexploited, but had additional problems with its natural and even artificial regeneration. Farmers had tried, without success, to grow this plant in nurseries. Seeds are attacked by a bruchid (Coleoptera: Bruchidae). In a sample of 53 fruits collected by the first author, 75% were damaged substantially by the insect and an additional 12% were decayed. Also, the seedlings are very sensitive to fire, and die during the grass fires laid every 2–3 years by the farmers in order to control weeds and rejuvenate their pastures (this is much cheaper than manual weeding or herbicides).

Species important for wildlife

Again, two-thirds of the species (70% of 76) were considered important for wildlife by the participants of the workshops and key informants. The most valuable species were *Ficus cotinifolia*, *Calyptranthes schiedeana* and *Maclura tinctoria,* all of them because their fruit provides food for animals. The ten species with the highest Wildlife Importance Perception Index value concentrated 49% of the value of the index. Moraceae was the most important family, with three species (Table 3).

Wildlife reported in the workshops and interviews consisted of eight mammals and one reptile (a spiny-tailed iguana); birds and frugivorous bats were considered as a group each. Birds were provided with food or shelter by 43 species, squirrels by 10 species and white-tailed deer by 9 species (Appendix Table 4, Fig. 4).

Several cultivated fruit trees were important food resources for wildlife, especially the native *Manilkara zapota* and *Spondias purpurea*. *Manilkara* requires humid soils year-round, so it was found mainly in home gardens and near rivers. *Spondias* can grow in dry soil, so it was found in live fences, as well as in home gardens. Also, the exotic mango (*Mangifera indica* L.) and tamarind (*Tamarindus indicus* L.) were frequently mentioned as important for animals. Wildlife was relevant for farmers, both for hunting and because animals may cause damage to crops.

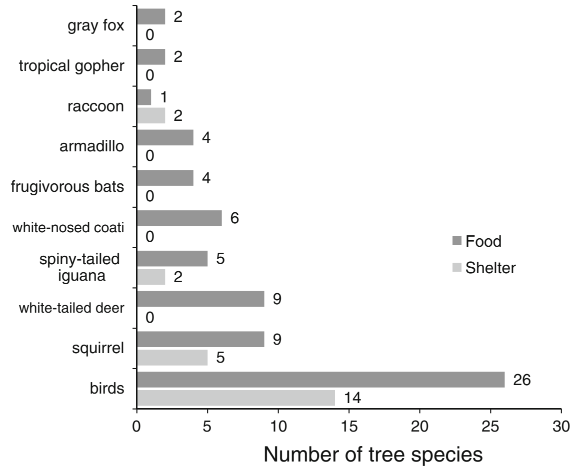

Fig. 4 Number of native woody species that provide food or shelter to wildlife, according to the informants interviewed during fieldwork in the municipalities of Paso de Ovejas and Comapa, Veracruz, Mexico. Gray Fox: *Urocyon cinereoargenteus* Schreber, 1775; tropical gopher: *Orthogeomys hispidus* (Le Conte, 1852); raccoon: *Procyon lotor* Linnaeus, 1758; armadillo: *Dasypus novemcinctus* Linnaeus, 1758; white-nosed coati: *Nasua narica* Linnaeus, 1766; spiny-tailed iguana: *Ctenosaura acanthura* Shaw, 1802; white-tailed deer: *Odocoileus virginianus veraecrucis* Goldman & Kollegg, 1940 squirrel: *Sciurus aureogaster* F. Cuvier, 1829

Discussion

Importance of the ethnobotanical approach

A study of the canopy of ten mature forest fragments in the same region as our study area (Williams-Linera and Lorea 2009) recorded 98 trees, with only 39 (40%) coinciding with this work. Another study of the secondary vegetation (five plots) of the same area found 33 species (Hernández 2008), of which only half (17) coincided. This study shows that the ethnobotanical approach is an important complement for regional forestry inventories, because it contributes taxa of secondary vegetation, agroforestry systems and riparian sites, that are not covered by other types of surveys.

In contrast, a study of the agroforestry systems of El Limón (Bautista 2009), adjacent to our study area, found 63 native species, of which 82% coincided. This shows that our study covered most common species of agroforestry systems used in smallholder agriculture of the region, as farmers promote useful species and eliminate unwanted ones. Also, our data show that farmers are quite knowledgeable not only about uses, but also on subjects relevant for conservation, such as wildlife habitat.

Useful species

The number of native, useful woody species found in this study was higher than those reported in other investigations carried out in the center of the State of Veracruz (21—Couttolenc-Brenis et al. 2005, in Camarón de Tejeda; 34—Leyva 2006, two localities of Paso de Ovejas; 63—Bautista 2009, one locality of the same municipality). Figueroa (2000) found 53 useful species in a community in the south of the State of Mexico with a similar vegetation type. In a larger Mesoamerican context, Joya et al. (without date) identified 70 useful species, both native and introduced, in the cattle ranches of the Pacific coast of Nicaragua.

Those results can be explained both by different sampling methods, and by an approximate relationship between the size of the study site and the number of useful woody species found. Very small studies report 20–30 species; a larger area, such as a village and its surroundings with some natural vegetation, have around 50 species (Figueroa 2000), and larger-scale regional studies report 70–80 useful species.

We confirmed that the traditional agroforestry systems can play an important role both in the conservation of the genetic diversity of the region and in improving local livelihoods, through the production of a variety of goods, especially fuel, fenceposts and timber. These systems are adapted to the way of life and the economic constraints on farmers (Ouinsavi and Sokpon 2008), though there appears to be some room for improvement.

For example, seven of the ten species with the highest Cultural Importance Index value were legumes of secondary vegetation. Improving the availability, conservation and management of these species should be possible with just some training and/or minimal investigation. Particularly *Lysiloma acapulcense*, a common species in Mexico and one of the most useful ones, could be promoted by systematic collection of seeds, nursery propagation and a better fire management in the pastures. This species, to our knowledge, is not included in government or NGO nurseries of the region.

Some Mesoamerican species found to be useful, such as *Leucaena* and *Gliciridia*, are widely grown in other parts of the world, to the point of having cultivars adapted to different habitats. However, in this region it is rare to encounter them in government or NGO nurseries, and cultivars are unknown. We do not know if this is due to technical difficulties, cultural reasons of the providers or because farmers do not demand them. *Leucaena* and *Gliciridia* are available to farmers without much effort. They are more interested in species that are not easily available, such as *Lysiloma acapulcense* and *Chloroleucon mangense*. These are not available in nurseries and represent an opportunity and challenge for tropical forestry research.

Ethnobotanical methods could also assist in the systematic searches for superior germplasm for these species. It is well-known that Mesoamerican farmers manage useful species in situ, often selecting desirable lines (see the overview by Casas et al. 2007). Though this characteristic has been studied mainly for fruit trees, local knowledge on desirable traits and ecology should also be useful for these multipurpose species.

Most of the forage species found are well-known and studied. They are particularly important for ruminants during the dry season (Carranza-Montaño et al. 2003; Cecconello et al. 2003; Román et al. 2004). Their exploitation could be improved in the study region through systematic harvest, milling and rationing, particularly of legume fruit. For example, *Enterolobium cyclocarpum* has a reputation in the region for causing bloating in cattle and is often removed from pastures for this reason. However, investigations by Zamora et al. (2001) in Nicaragua showed that milling and rationing converts these abundant fruit into a very useful component of mixed rations. Trees could also be employed for improving stocking and rotations (Bautista 2009).

The timber species of the region are important germplasm adapted to seasonally dry, tropical regions. *Cedrela odorata*, *Tabebuia rosea*, *Astronium graveolens, Enterolobium cyclocarpum,* and *Gyrocarpus jatrophifolius* have excellent timber. They could improve the long-term value of the secondary vegetation that 68% of the farmers have on their properties (Línea 2008), through enrichment planting, particularly if management (spacing, pruning, pest control) helps to raise quality. Of these, only *Cedrela* is obtainable from official nurseries, however, monocultures of this species have pest problems and suffer in droughts.

While it is possible to sell good-quality timber to carpenters, traditionally most timber has been used in the past for self-construction. Traditional use is in decline, because cement and block constructions are considered a sign of progress (even though people widely acknowledge that they are much less comfortable than traditional constructions in the tropical climate).

The same process of devaluation of local custom could be observed with other uses, such as hammocks made of ixtle (*Agave* fiber) and straw brooms with a handle of *Guazuma ulmifolia* wood. Here, systematic stimulus and revaloration could improve the status of these uses, and with it the appreciation of timber species. Gordon et al. (2003) emphasize the fact that prohibition of use of certain species for conservation purposes, can also lead to a loss of interest in a species.

The food products of the trees were not usually commercialized, but diversified the diet of the local population and are a potential resource for genetic improvement and domestication.

Scarce species

Of the ten species considered to be the scarcest, five were also among the ten most important trees culturally (*Diphysa carthagenensis*, *Lysiloma acapulcense*, *Chloroleucon mangense*, *Caesalpinia cacalaco*, *Cedrela odorata*), because of their utility as good-quality fuel and source of fenceposts. Most of them were rare in natural forest fragments (Williams-Linera and Lorea 2009) and secondary vegetation (Hernández 2008) of the region, though they may be relatively common in agroforestry systems (Bautista 2009). This is not due to the forests and secondary vegetation being commons (which they are not) and the latter being private, but rather to habitat requirements. Scarce does not necessarily mean rare, but rather not sufficient for the desired level of exploitation. Barrance et al. (2003) found a similar situation in the south of Honduras, where the overexploitation of a few highly useful species led to the perception of scarceness, though they might not be rare. The results point to high level pressure on these species, and an opportunity for their inclusion in tree-planting schemes.

None of the ten species perceived as the scarcest appear in the official list of protected species (SEMARNAT 2002—Norma Oficial Mexicana NOM-059-ECOL-2001). The Mesoamerican trees *Astronium graveolens* and the widely used *Tabebuia chrysantha* are mentioned in this list as endangered but not endemic to Veracruz. These species were restricted to natural vegetation in the study area. *Astronium* was known only to a few people and has a use that is almost extinct today: for beams or rafters of the large houses of the haciendas. After the abandonment of the haciendas, some of these beams were integrated into current houses or corrals; some are still in use and estimated to be more than 200 years old.

Beaucarnea recurvata, which is also listed as endangered and endemic, was not mentioned as scarce, only as important for birds. There were no large populations in the area—the individuals in pastures suffered from fire, so the only large, wild specimens were found in canyons. However, they were widely cultivated as ornamentals in home gardens, and were probably perceived as common for this reason.

There were two species of *Bursera, B. simaruba* and *B. cinerea*, that were not perceived as different by the population: both were called "mulato". They were considered scarce and with declining populations, mainly because of the influence of fire. However, *B. simaruba* is a common species elsewhere and widely distributed in the Mexican tropics, whereas *B. cinerea* is a narrow endemic of the center of Veracruz. It used to be very common in primary dry forests (Castillo-Campos et al. 2005; Rzedowski and Calderón de Rzedowski 1996).

Some of the scarce and useful species could be particularly interesting for promotion, even though they obtained low values in the Scarcity Perception Index. An example is *Randia monantha*; an alcoholic (rum) extract of its fruit is employed as an antidote for the bites of snakes, scorpions, wasps and spiders, both for humans and domestic animals. Some farmers have transplanted seedlings from the forest to their home gardens, but none of them reported to have fruit. It is a dioecious species, so it would be necessary to have at least a small population to assure fruit set.

Scarce and rare species are an important component of the diversity of an ecosystem. Without them, restoration and conservation efforts are incomplete (Lamb and Gilmour 2003). This study shows that interviewing the local population on useful, important

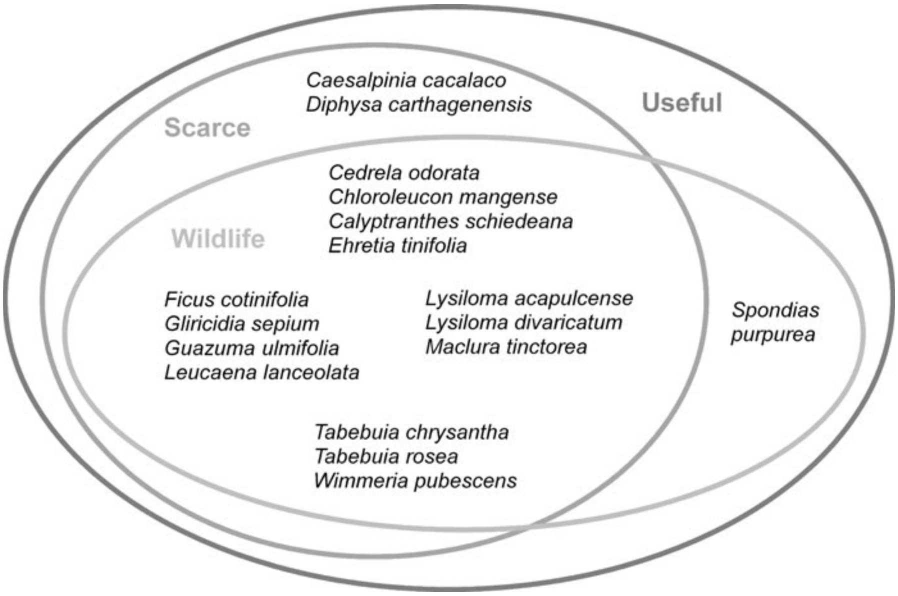

Fig. 5 Summary of the information on the most important woody species of the study area. The species mentioned should be explored further for their inclusion in reforestation and agroforestry projects

and scarce species leads to interesting and fruitful answers; particularly it helps to trace the history and dynamics of the species and their response to human disturbance (Lykke 1998; Lykke et al. 2004).

Species relevant for wildlife

In this study, *Ficus cotinifolia* was perceived as the most important species for food and habitat of animals. This confirms the result of numerous ecological studies in the tropics, which show that *Ficus* trees are frequently a keystone plant resource, because they sustain frugivorous animal species and communities through periods of resource scarcity (Terborgh 1986). However, species with a very wide crown, such as *Ficus cotinifolia* or *Maclura tinctoria* were unwelcome in small pastures. They were more attractive for large lots or rocky sites. *Calyptranthes schiedeana* was a species with a smaller crown, which was also attractive for wildlife, and it is endemic to Veracruz.

Water sources during the dry season are of prime importance for wildlife anywhere. Some tree species provided alternative sources of water in this time of the year, for example, the flowers of *Ceiba* and the fruit of *Spondias* and *Ficus* for the white-tailed deer (Villarreal Espino-Barros and Marín 2005). Another important consideration was animals that disperse tree seeds, such as the white-nosed coati (*Nasua narica*) (Sáenz 1994; Valenzuela 1998). The farmers mentioned six tree species that provide food to the coati, among them *Genipa americana* var. *caruto*. Cattle also like the fruit, and it is probably a water source for them as well.

There was an indirect benefit of conserving wildlife (apart from their intrinsic conservation value): 18 species of animals were used either as food or as medicine, especially among less well-off people (Leyva 2006). The species that provide food and habitat to the local spiny-tailed iguana (“tilcampo”, *Ctenosaura acanthura*) could be important if this species were to be domesticated, as it is a very popular food, but also an endemic species subject to special protection under NOM-059-ECOL-2001.

Species selection for restoration

A combination of the top third of the species of each index results in 17 species that we suggest should be the primary candidates for restoration and reforestation programs. This is a manageable number, particularly as the local population already knows successful propagation techniques, though sometimes rudimentary, and will be interested in the success of the planting. Only two of these (*Cedrela* and *Tabebuia rosea*) are currently available in the nurseries of the region. Moreover, 16 are considered scarce and 15 important for wildlife (Fig. 5).

Conclusions

The results of this study provide information that is useful for formulating and implementing sustainable management alternatives that will allow conservation and restoration of tropical dry forest to proceed in practice. The methods used in this study are viable and practical, and allow a preliminary selection of woody species for restoration purposes, when no detailed information is available on the vegetation and ecology of a region. It shows that the species cultivated in formal nurseries are often not those that would be the most useful or appropiate for the rural population. Of the species cultivated in these, only *Cedrela* and *Tabebuia rosea* are considered important both by nurseries and by the interviewed farmers.

Relatively little is known about tree species selection and appropriate techniques for restoring dryland forests in Latin America (Newton 2008). The standard strategy is the planting of mainly exotic timber species, for which technical knowledge is readily available. This strategy frequently fails, for various reasons. Studies such as this one are necessary to improve species selection, in order to increase acceptance and interest of the local population in woody species for restoration, as well as to formulate practical management recommendations.

Data generated from this study will revert to the local people. All the gathered information is being included in a guide of the trees of the region. Additionally, some species were evaluated technically in restoration experiments (Williams-Linera et al. 2011). The project ReForLan has integrated general guidelines for the restoration of drylands to be adapted to the conditions of several dry forest regions into a book (Newton and Tejedor 2011). The results have become even more topical after the extensive destruction of Hurricane Karl in Veracruz in September 2010, which extensively damaged existing woodlands and human settlements and underscored the necessity of forest recovery to slow runoff and reduce flooding.

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Appendix

See Table 4.

Table 4 Species and local names of tropical dry forest trees in the study area of central Veracruz, Mexico

Species	Name	LF	TP	Categories			Types of uses												Wildlife importance	
				Us	Sc	Wl	co	ed	po	fu	me	fe	or	fo	to	sh	ti	ha	Food	Habitat
Agavaceae																				
Agave sp.	ixtle	Sh	F S	0	3	0	1	–	–	–	–	–	–	–	–	–	–	2	–	–
Yucca sp.	izote	Sh	F A	1	0	1	–	2	–	–	1	–	2	–	–	–	–	–	sq	–
Anacardiaceae																				
Astronium graveolens Jacq.	gateado	T	F	1	1	1	1	–	–	–	–	–	–	–	–	–	2	–	bi	bi
Comocladia engleriana Loes.	tetlatín	T	F A	8	6	3	1	1	1	–	–	1	–	–	–	–	–	–	bi	bi
Spondias mombin L.	jobo	T	F	0	1	5	–	1	–	–	–	–	–	–	–	–	–	–	ba bi	–
Spondias purpurea L.	ciruela	T	F A	11	0	27	–	2	–	–	–	2	–	–	–	–	–	–	bi de ig	–
Annonaceae																				
Annona purpurea Moc. & Sessé ex Dunal	ilama	T	S A	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	bi	–
Annona sp.	anono	T	F	0	2	0	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Arecaceae																				
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	coyol redondo	T	S A	0	0	1	1	1	–	–	–	–	–	–	–	–	–	–	–	bi
Bignoniaceae																				
Astianthus viminalis (Kunth) Baill.	sauce	T	R	1	0	0	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Crescentia alata Kunth	jicaro	T	F A	0	4	0	–	–	–	–	1	–	–	–	–	–	–	1	de	–
Parmentiera sp.	cuajilote	T	A	0	6	0	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Tabebuia chrysantha (Jacq.) G. Nicholson	flor de dia	T	F S A	24	6	1	3	–	2	1	–	1	2	–	2	–	–	–	sq	bi
Tabebuia rosea (Bertol.) A. DC.	roble	T	F A	7	13	1	3	–	–	–	1	–	2	–	2	–	3	–	sq de	–
Boraginaceae																				
Cordia alliodora (Ruiz & Pav.) Oken	tres hojas	T	F S A	1	0	0	2	–	–	1	–	–	–	–	1	–	1	2	–	–
Cordia dentata Poir.	moquillo	T	S A	0	1	1	–	–	1	–	–	2	–	–	1	–	–	–	bi	–
Ehretia tinifolia L.	frutillo, palo verde	T	F A	12	5	26	–	–	–	–	–	–	1	–	–	3	–	–	bi ar	bi
Burseraceae																				
Bursera cinerea Engl.	mulato	T	F A	9	5	1	2	–	–	–	1	2	–	–	–	–	–	–	bi	–
Bursera graveolens (Kunth) Triana & Planch.	aceitillo	T	F	0	3	0	–	–	–	–	2	1	–	–	–	–	–	–	–	–

Table 4 continued

Species	Name	LF	TP	Categories			Types of uses												Wildlife importance	
				Us	Sc	Wl	co	ed	po	fu	me	fe	or	fo	to	sh	ti	ha	Food	Habitat
Bursera simaruba (L.) Sarg.	mulato	T	F A	9	5	1	2	–	–	–	1	2	–	–	–	–	–	–	bi	bi
Cactaceae																				
Neobuxbaumia sp.	organo, organo de tuna	T	F	1	0	9	1	–	–	1	–	–	–	–	–	–	–	–	bi	–
Nopalea sp.	nopal	Sh	F	0	0	6	–	1	–	–	–	–	–	–	–	–	–	–	bi	–
Celastraceae																				
Wimmeria pubescens Radlk.	camarón, camaroncillo	T	F	3	16	1	–	–	1	–	1	–	–	–	–	–	–	–	bi	–
Convolvulaceae																				
Ipomoea wolcottiana Rose	patancán	T	F S	7	5	4	–	2	–	–	–	–	–	–	–	–	–	–	–	bi
Euphorbiaceae																				
Croton reflexifolius Kunth	quina	Sh	S	5	3	0	–	–	–	1	1	–	–	–	–	–	–	–	–	–
Fabaceae																				
Acacia cochliacantha Humb. & Bonpl. ex Willd.	espino blanco	T	S A	21	11	2	–	–	2	3	–	–	–	2	–	–	–	–	–	bi
Acacia pennatula (Schltdl. & Cham.) Benth.	huizache	T	S A	4	5	1	–	–	2	3	–	–	–	3	–	–	–	–	–	bi
Albizia saman (Jacq.) F. Muell.	garrobo	T	F A	0	2	0	–	–	–	–	–	–	1	1	–	–	2	–	–	–
Caesalpinia cacalaco Bonpl.	tihuixtle, tehuixtle	T	S A	23	11	0	–	–	3	–	–	2	–	2	–	–	–	–	–	–
Caesalpinia pulcherrima (L.) Sw.	caballero, espuela de caballero	T	S A	3	3	0	–	–	1	1	1	–	2	–	–	–	–	–	–	–
Chloroleucon mangense (Jacq.) Britton & Rose	moreno, palo amarillo	T	F S A	39	22	1	2	–	3	2	–	1	–	2	2	–	–	–	–	bi
Diphysa carthagenensis Jacq.	quiebra hacha	T	F S A	32	35	0	2	–	2	3	–	1	–	–	–	–	–	–	–	–
Enterolobium cyclocarpum (Jacq.) Griseb.	nacaxtle	T	F S A	14	10	10	3	–	–	–	–	–	–	1	–	2	3	–	bi	bi ig ra
Erythrina sp.	colorín	T	F A	3	1	0	–	1	–	–	1	–	2	–	–	–	–	–	–	–
Eysenhardtia polystachya (Ortega) Sarg.	taray	T	S	1	8	0	–	–	1	–	3	–	–	–	–	–	–	–	–	–
Gliricidia sepium (Jacq.) Kunth ex Walp.	cocuite	T	S A	15	3	1	–	1	3	1	–	2	–	1	–	–	–	–	–	bi
Haematoxylon sp.	brasil	T	F	1	2	0	–	–	–	–	1	–	–	–	–	–	–	–	–	–
Inga sp.	chalaguite	T	R	1	0	0	–	1	–	–	–	–	1	–	–	–	–	–	–	–
Leucaena lanceolata S. Watson	guaje de indio	T	S A	24	9	3	2	2	3	2	–	1	–	2	–	–	–	–	de	–

Table 4 continued

Species	Name	LF	TP	Categories			Types of uses												Wildlife importance	
				Us	Sc	Wl	co	ed	po	fu	me	fe	or	fo	to	sh	ti	ha	Food	Habitat
Leucaena leucocephala (Lam.) de Wit	guaje, guaje manso	T	S A	3	0	2	1	2	–	1	–	–	–	–	–	–	–	–	de	–
Lysiloma acapulcense (Kunth) Benth.	guaje sabana, cañamazo	T	F A	40	28	2	3	–	3	–	–	–	–	–	3	2	–	–	bi sq	sq
Lysiloma divaricatum (Jacq.) J.F. Macbr.	tepeguaje, mezquite	T	F A	8	10	1	2	–	2	2	–	–	–	–	–	–	–	–	bi sq	sq
Senna atomaria (L.) H.S. Irwin & Barneby	frijolillo	T	S A	16	6	1	–	–	2	2	–	–	–	2	–	–	–	–	–	bi
Hernandiaceae																				
Gyrocarpus jatrophifolius Domin	palo banco	T	F	1	2	0	2	–	–	–	–	–	–	–	–	–	1	–	–	–
Malpighiaceae																				
Byrsonima crassifolia (L.) Kunth	nanche	T	A	10	6	9	–	2	–	–	–	1	–	–	–	–	–	–	ba bi	–
Malpighia emarginata DC.	manzanita	T	F A	0	0	3	–	1	–	–	–	–	–	–	–	–	–	–	bi	bi
Malvaceae																				
Ceiba aesculifolia (Kunth) Britten & Baker f.	pochote	T	F	0	0	6	–	–	–	–	–	–	–	–	–	–	–	1	de	–
Ceiba pentandra (L.) Gaertn.	ceiba	T	F A	1	1	4	–	–	–	–	–	–	1	–	–	2	–	–	–	bi
Guazuma ulmifolia Lam.	guazamo	T	S A	8	1	26	–	–	–	2	2	–	–	3	–	–	–	3	bi ig de	–
Heliocarpus donnellsmithii Rose	jonote	T	F S	4	7	0	2	–	–	–	–	–	–	1	–	–	–	–	–	–
Luehea candida (Moc. & Sessé ex DC.) Mart.	algodoncillo	T	F	5	2	0	–	–	1	–	–	–	–	–	1	–	–	–	–	–
Meliaceae																				
Cedrela odorata L.	cedro	T	F A	30	7	1	–	–	–	–	–	–	2	–	3	–	3	–	–	bi ra
Moraceae																				
Brosimum alicastrum Sw.	ojite	T	F	2	4	15	2	1	–	–	–	–	–	2	–	–	–	–	bi ig sq ba	sq
Castilla elastica Sessé ex Cerv.	palo hule	T	R	0	1	0	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Ficus cotinifolia Kunth	higuera, higuera de burro	T	F A	4	7	53	–	–	–	–	–	–	1	1	–	3	–	–	ig ar co fo sq	ig sq
Maclura tinctoria (L.) D. Don ex Steud.	moral	T	F S A	18	2	17	3	1	3	–	1	–	–	–	–	2	–	–	ba bi sq ra	bi sq
Myrsinaceae																				
Ardisia sp.	capulín de mayo	Sh	F A	0	0	3	–	1	–	–	–	–	–	–	–	–	–	–	bi	–
Myrtaceae																				

Table 4 continued

Species	Name	LF	TP	Categories			Types of uses												Wildlife importance	
				Us	Sc	Wl	co	ed	po	fu	me	fe	or	fo	to	sh	ti	ha	Food	Habitat
Calyptranthes schiedeana O. Berg	guayabillo	T	F A	7	7	40	2	1	2	–	–	1	–	–	–	–	–	–	bi sq ar co go	sq
Eugenia hypargyrea Standl.	mataejuan	T	F	0	0	2	–	–	–	1	–	–	–	–	–	–	–	–	co go fo	–
Non identified 1	raijan	Sh	F	0	0	5	–	1	1	–	–	–	1	–	1	–	–	–	bi	–
Non identified 2	garrapatillo	T	F	1	1	0	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Olacaceae																				
Schoepfia schreberi J.F. Gmel.	palo meco	T	F S	4	0	0	–	–	–	–	2	–	–	–	–	–	–	–	–	–
Fraxinus schiedeana Schltdl. & Cham.	caliche	T	F	1	0	0	1	–	–	2	–	–	–	–	–	–	–	–	–	–
Phytolaccaceae																				
Achatocarpus nigricans Triana	palo dulce	Sh	S	0	0	3	–	–	–	–	–	1	–	–	–	–	–	–	bi	–
Polygonaceae																				
Coccoloba barbadensis Jacq.	overo, uvero	T	F S	2	12	0	1	1	–	–	–	–	–	–	1	–	–	–	bi	–
Coccoloba sp.	cerezo	T	F	0	0	2	–	1	–	–	–	–	–	–	–	–	–	–	bi	–
Rhamnaceae																				
Colubrina triflora Brongn. ex Sweet	canelillo	T	S	15	5	0	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Colubrina heteroneura (Griseb.) Standl.	huesillo	T	F	1	0	0	–	–	1	–	–	–	–	–	–	–	–	–	bi	–
Rubiaceae																				
Genipa americana var. *caruto* (Kunth) K. Schum.	yoal, yuhal	T	F A	0	2	2	–	1	–	–	–	–	–	1	–	1	–	–	bi co de	–
Randia monantha Benth.	crucetillo	Sh	F A	3	3	1	–	–	–	–	3	–	–	–	–	–	–	–	bi	–
Ruscaceae																				
Beaucarnea recurvata Lem.	monja	T	F	0	0	2	–	–	–	–	–	–	3	–	–	–	–	–	–	bi
Sapindaceae																				
Thouinidium decandrum (Bonpl.) Radlk.	borreguillo	T	S A	1	0	1	–	–	–	–	–	–	–	–	–	1	–	–	ig	–
Sapotaceae																				
Manilkara zapota (L.) P. Royen	zapote chico	T	A	4	4	19	1	3	–	–	–	–	–	–	–	–	–	–	bi sq co	–
Sideroxylon celastrinum (Kunth) T.D. Penn.	pionche, pionchillo	T	F A	0	0	12	–	1	–	–	–	–	1	–	–	2	–	–	ar bi	bi
Simaroubaceae																				

Table 4 continued

Species	Name	LF	TP	Categories			Types of uses												Wildlife importance	
				Us	Sc	WI	co	ed	po	fu	me	fe	or	fo	to	sh	ti	ha	Food	Habitat
Simarouba glauca DC.	cedro blanco pistache	T	F A	1	0	2	1	–	–	–	–	–	2	–	–	–	1	–	bi	–
Unknown family																				
Non identified	mano de león	T	F	1	0	1	1	–	–	–	1	–	–	–	–	–	–	–	co	–

LF is life form (T is tree, Sh is shrub); TP is type of vegetation (F is forest, S is secondary vegetation, R is riparian forest and A is agroforestry); species categories are useful (Us), scarce (Sc) and wildlife important (WI); the values are frequency of mention in the workshops. Type of uses are *co* construction, *ed* edible, *po* fence post, *fu* fuel, *me* medicinal, *fe* living fence, *or* ornamental, *fo* forage, *to* tools, *sh* livestock shade, *ti* timber, and *ha* handicraft; the numbers indicate the level of the use (1 = low, 3 = high). Wildlife importance are for food and habitat (*bi* birds such as calandria, parrot, etc. and others, *ig* spiny-tailed iguana, *ar* armadillo, *ra* racoon, *sq* squirrel, *ba* frugivorous bats, *co* white-nosed coati, *go* tropical gopher, *de* white-tailed deer, *fo* gray fox)

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