Traditional Knowledge and Useful Plant Richness in the Tehuacán–Cuicatlán Valley, Mexico[1]

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Traditional Knowledge and Useful Plant Richness in the Tehuacán–Cuicatlán Valley, Mexico. This study systematizes ethnobotanical information about the interactions between people and plants, ethnofloristic richness, the relative importance of useful species richness in relation to general species richness, and plant management in the Tehuacán–Cuicatlán Valley of central Mexico. The study recorded a total of 1,605 useful vascular plant species (61.2% of the total species richness of the regional vascular flora), this being the region with the highest absolute richness of useful plant species in Mexico. The null hypothesis that plant families with a higher number of useful species would be those having a higher general species richness was analyzed through residuals method. The plant families richest in useful species were Poaceae, Asteraceae, Cactaceae, Cyperaceae, Mimosaceae, and Solanaceae, most of which also have the highest general floristic richness. However, analyses of use categories did not generally corroborate our hypothesis. About 1,335 of the useful species are wild, more than 500 species are submitted to some type of management (62 species are tolerated, 34 protected, 50 enhanced, and 358 cultivated), but only a few have been studied to document their process of domestication. This information can be useful for developing regional strategies of sustainable management of plant resources.

Conocimiento tradicional y riqueza de plantas útiles en el Valle de Tehuacán-Cuicatlán, México. Este trabajo sistematiza información etnobotánica sobre las interacciones entre la gente y las plantas, la riqueza etnoflorística, la importancia relativa de las especies útiles con respecto a la riqueza florística general, y sobre el manejo de plantas en el Valle de Tehuacán–Cuicatlán, en el centro de México. Se registró un total de 1,605 especies de plantas vasculares útiles (61.2% de la riqueza total de la flora vascular de la región), lo que identifica a la región como la de mayor riqueza de plantas útiles de México en términos absolutos. Mediante el método de residuales se analizó la hipótesis nula de que las familias con mayor número de especies útiles serían las de mayor riqueza florística. Se encontró que las familias con mayor número de especies útiles fueron Poaceae, Asteraceae, Cactaceae, Cyperaceae, Mimosaceae, y Solanaceae, las cuales en su mayoría son las de mayor riqueza florística en la región. No obstante, al efectuar el análisis por categorías de uso no siempre se confirmó nuestra hipótesis. Casi 1,335 de las plantas útiles son silvestres, pero alrededor de 500 están sometidas a algún tipo de manejo (62 especies son toleradas, 34 protegidas, 50 fomentadas y 358 cultivadas), pero sólo para algunas de ellas se ha estudiado cómo operan los proceso de domesticación. La información generada en el trabajo puede ser útil para el desarrollo de estrategias regionales de manejo sustentable de los recursos vegetales.

Key Words: Ethnobotany, Tehuacán–Cuicatlán Valley, traditional plant management, residual analysis, México.

Introduction

The cultural area known as Mesoamerica, between central Mexico and northern Costa Rica, is currently recognized as one of the most important centers of cultural diversity and biological richness of the world (Hernández-Xolocotzi 1993; Rzedowski 1993; Toledo et al. 1997). Humans and plants have interacted here for nearly 12,000 years (MacNeish 1992). Local Mesoamerican peoples have developed

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an extraordinary complex of interaction with plants, including the gathering of wild plants, several forms of *in situ* or silvicultural management of wild plant populations and communities, and the cultivation and selection of particular varieties to be used in specific environmental and cultural conditions (Caballero 1984; Bye 1993; Casas et al. 1997a, 2007).

Such a long and systematic interaction has led to the construction of rich knowledge profiles regarding the use and management of a wide range of plant species. It has been estimated that nearly 5,000 to 7,000 plant species are used in Mexico, including their immense infra–specific variation (Caballero 1984; Casas et al. 1994). Nearly 90% of the useful plant species are native wild species obtained through gathering (Caballero et al. 1998), whereas nearly 20 plant species (such as corn, beans, cocoa, chili peppers, cotton, and squashes) are important economic crops on a global scale and whose extraordinary diversity of land races and populations of wild relatives constitute highly relevant genetic resources. Some other native Mexican species (nearly 200 species, according to Casas and Parra 2007) are in the early and intermediate stages of domestication. All of them and their wild relatives are not only important on a local or regional scale, but also represent a bulk of potential plant resources that have not been well studied, although they have already been documented by various ethnobotanical studies, such as those reported by Alcorn (1984), Bye (1993), Caballero and Mapes (1985), Caballero et al. (2000), Casas and Caballero (1996), Casas et al. (1996, 1997a, 1999a, 2001, 2007), Lira (2004), Lira and Caballero (2002), Lira and Casas (1998), Martínez-Alfaro et al. (1995), and Zizumbo-Villarreal and Colunga-García-Marín (1982).

The Tehuacán–Cuicatlán Valley is one of the Mexican areas where the relationships between humans and plants have been relevant in the past and still are today. In this region, the interactions between local people and plants from prehistory to the present day have been documented (MacNeish 1967; Smith 1967; Casas et al. 2001). However, until the end of the last century, ethnobotanical studies were relatively scarce in this area. Miranda (1948), Smith (1965, 1967), Casas and Valiente-Banuet (1995), and Casas et al. (1997a) conducted some of the most relevant work.

Casas et al. (2001) synthesized the ethnobotanical information generated in the region until the beginning of the present century. It included an inventory of common names, uses, and management levels for 808 species of vascular plants from seven municipalities of the region, as well as an analysis of the ethnofloristic importance of the Tehuacán Valley compared with other regions of Mexico. The result of this analysis highlighted the valley as one of the most important regions of Mexico in terms of richness of traditional knowledge of plants. In the last few years, however, our group has conducted a series of new studies in the area, which have contributed to the depth of the ethnobotanical framework and to the expansion of the spatial, ecological, and cultural limits covered in the previous study (Casas et al. 2001). The new data practically double the number of useful flora reported by those authors. Therefore, new analyses of the information are necessary considering the outstanding richness of ethnobotanical knowledge documented and considering the importance of the region in the study of the history of interactions between humans and plants that led to the origins of agriculture.

Accordingly, this study aimed to report and systematize the ethnobotanical investigations carried out to date. Particular attention was given to information on the regional ethnofloristic richness, since the Tehuacán–Cuicatlán Valley is the area of Mexico with the richest useful flora reported hitherto. Also, an analysis was undertaken to evaluate the relative importance of plant families in relation to their richness of useful plant species and their general floristic richness in the region. And finally, information on various forms of plant management occurring in the region were also analyzed in the context of one of the most important scenarios of domestication of plants recognized in Mexico by archaeological and ethnobotanical studies.

Study Area

The Tehuacán–Cuicatlán Valley constitutes a floristic province belonging to the Mexican Xerophytic Region (Rzedowski 1978). It is located in the southern part of the state of Puebla and the northern portion of the state of Oaxaca (Fig. 1). The surface of the valley is about 10,000 square kilometers (km^2), the region forming a complex physiographic mosaic with several internal valleys separated by mountain chains. The climate is predominantly semiarid, with an annual mean temperature of 21°C and an annual mean

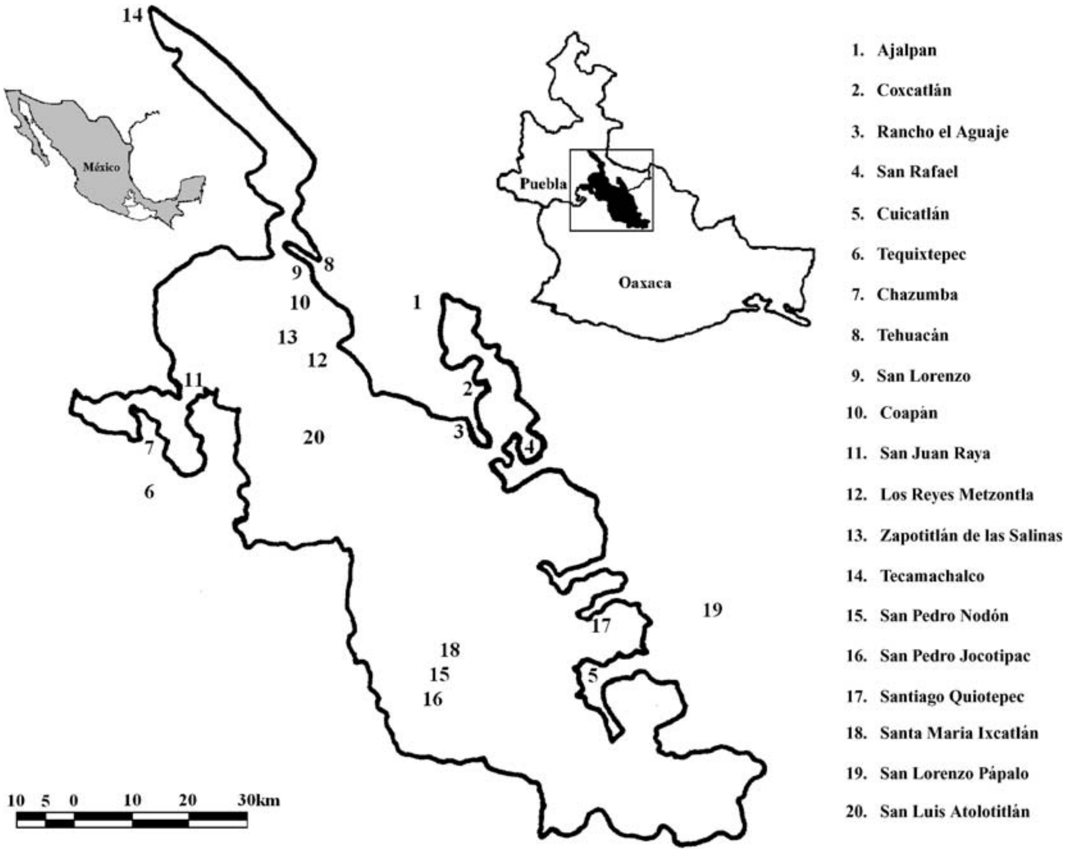

Fig. 1. Geographic position of the Tehuacán–Cuicatlán Valley and the localities where the ethnobotanical information was gathered.

precipitation of 400 millimeters (mm) (Villaseñor et al. 1990). The dryness of the region is the result of the orographic rain shadow effect produced by the Oriental Sierra Madre (Villaseñor et al. 1990; Valiente-Banuet 1991; Dávila et al. 2002). The altitude of the floor of the valley ranges from 2,200 meters (m) in the northwest to about 600 m in the southeast; the dryland area is below 1,800 m. This region has been recognized as a center of megadiversity and endemism by the World Conservation Union (IUCN) and, in 1998, most of its territory was decreed as part of the Tehuacán–Cuicatlán Biosphere Reserve (Dávila et al. 1993, 2002; Mendez-Larios et al. 2005). Its vascular flora comprises 2,621 species and 48 infra–specific taxa of 180 families and 890 genera, with between 9.1% and 13.9% of the plant species being endemic to the region (Dávila et al. 1993, 2002; Mendez-Larios et al. 2004, 2005). At the plant community level, Valiente-Banuet et al. (2000) have identified 30 different plant association types.

The biological richness recorded at this point in time includes 57 species of mosses (Delgadillo and Zander 1984), 34 species of bats (Rojas-Martínez and Valiente-Banuet 1996), 141 species of birds (Arizmendi and Espinoza de los Monteros 1996), 24 species of Coreidae (Hemiptera–Heteroptera) (Brailovsky et al. 1994, 1995), and 24 species of ants (Ríos-Casanova et al. 2004), among other groups. Compared with other areas, these figures reveal that the Tehuacán–Cuicatlán Valley is probably the most diverse arid region of North America (Dávila et al. 2002) and it is now an important natural protected area of Mexico.

The Tehuacán–Cuicatlán Valley also has a high cultural diversity. Of the 57 indigenous ethnic groups that currently inhabit the Mexican territory (Toledo et al. 2001), seven (Nahua, Popoloca, Mazatec, Chinantec, Ixcatec, Cuicatec, and Mixtec) live in the valley. The region has been important in the reconstruction of the prehistory of Mesoamerica since archaeologists found in caves some the oldest remains of domesticated plants and agriculture in the New World (MacNeish 1967, 1992; Smith 1967). At present, the Tehuacán–Cuicatlán Valley is densely populated and its inhabitants undertake numerous economic activities, especially agriculture and livestock farming. However, there are areas with various levels of degradation and others that are well preserved, such as where people still practice the gathering of animal and plant products to complement their diet and daily subsistence (Casas et al. 2001; Pérez-Negrón and Casas 2007).

Methods

Ethnobotanical Surveys

Recent ethnobotanical studies were focused on undertaking inventories of the plant species used by local peoples, the indigenous nomenclature and forms of management, collecting and georeferencing herbarium specimens, and evaluating the use rates and spatial availability of plant resources. The studies comprised the villages of (1) Santa María Ixcatlán, in the municipality of Ixcatlán (Oaxaca), which is inhabited by Ixcatec people (the only village of this indigenous ethnic group in the World) (Rangel-Landa and Lemus 2002), (2) the village of San Rafael, in the municipality of Coxcatlán (Puebla) where mestizo people with Náhuatl cultural influence live (Rosas-López 2003; Blanckaert et al. 2004), (3) the villages of San Pedro Nodón and San Pedro Jocotipac, in the municipalities of Cuicatlán and Jocotipac (Oaxaca), respectively, which are inhabited by Mixtec people (Echeverría-Ayala 2003); (4) the village of San Luis Atolotitlán, in the municipality of Caltepec (Puebla), which is inhabited by mestizo people with Náhuatl cultural influence (Torres 2004); (5) the village of San Lorenzo Pápalo, in the municipality of Cuicatlán (Oaxaca) with the Cuicatec people, one of the endemic ethnic groups of the Tehuacán Valley (Solís 2006); (6) the village of Zapotitlán de las Salinas, in the municipality of Zapotitlán (Puebla), which is inhabited by mestizo people with Popoloca origins (Paredes-Flores et al. 2007); and (7) the village of Quiotepec, in the municipality of Cuicatlán (Oaxaca), with mestizo people (Pérez-Negrón and Casas 2007). Table 1 summarizes the information related to these study areas, and Fig. 1 shows their geographic localization in the Tehuacán–Cuicatlán Valley.

We determined the ethnofloristic richness of the Tehuacán–Cuicatlán Valley by systematizing in a database the information of all these case studies, including the data previously synthesized by Casas et al. (2001), and ethnobotanical information documented in studies on the domestication of columnar cacti (Casas et al. 1997b, 1999a, 1999b, 2006; Cruz and Casas 2002; Arellano and Casas 2003; Carmona and Casas 2005; Rodríguez-Arévalo et al. 2006; Blancas 2007; Parra et al. 2008), as well as other species such as *Sideroxylon palmeri* (González-Soberanis and Casas 2004), *Proboscidea louisianica* ssp. *fragans* (Paredes-Flores 2006), and *Ceiba aesculifolia* ssp. *parvifolia* (Avendaño et al. 2006).

General Floristic Richness and Richness of Resources of Plant Families

Our group analyzed the relative importance of plant families, in terms of general species richness and richness of useful plant species, through a residual analysis using the method developed by Moerman et al. (1999) and recently used by Caballero et al. (2004). Through this method, a regression of the total number of useful species and the number of species per use category per plant family, reported in the ethnobotanical studies referred above, was performed with respect to the total number of species per plant family reported for the region by Dávila et al. (1993, 2002) and Mendez-Larios et al. (2005). Databases constructed by those authors were compared with ours. After the regression was performed, the families were ordered hierarchically according to their residual values, which represent the difference between the predicted number of useful species obtained by the regression and the real number of species documented by the ethnobotanical studies. Accordingly, the families with higher positive residual values are those that are more favored as useful plants and/or for any particular use. In contrast, the families with negative residual values are those less frequently used or even ignored by people. Thus, this method was used to test the null hypothesis that if no use selectivity is practiced on particular groups of plant resources, the best–represented families in the flora will be those having higher number of useful species.

Table 1. General characteristics of the localities where the ethnobotanical information was gathered in the Tehuacán–Cuicatlán Valley.

Sites or Regions	Altitude (in meters)	Vegetation	Ethnofloristic Richness	Human Group	References
Municipalities of Zapotitlán Salinas (San Juan Raya, Los Reyes Metzontla), Tehuacán (San Lorenzo, Coapan, Tehuacán), Coxcatlán and Ajalpan (Ajalpan, San Rafael, Rancho El Aguaje, Coxcatlán), Cuicatlán (Cuicatlán, Tomellin, Valerio Trujano), Chazumba (Chazumba), and San Pedro and San Pablo Tequixtepec (Tequixtepec, Santa Catalina Chinango)	1,000–2,300	Thorn–scrub forest, tropical deciduous forest, and Mexical or Chaparral	808	Chocho–Popoloca, Nahua, Cuicatec, Mixtec, and Mestizo	Casas et al. (2001)
Zapotitlán Salinas	1,400–1,600	Thorn–scrub forest	288	Chocho–Popoloca and Mestizo	Paredes-Flores (2006), Paredes-Flores et al. (2007)
Santa María Ixcatlán	1,840	*Quercus* forest, *Juniperus flaccida* forest, riparian forest with *Taxodium mucronatum,* rosette scrub forest, or Izotal with *Beaucarnea gracilis*, Mexical or Chaparral, Palmar with *Brahea dulcis*.	376	Ixcateco	Rangel-Landa and Lemus (2002)
San Rafael	1,217	Thorn–scrub forest	368	Nahua and Mestizo	Blanckaert et al. (2004), Rosas-López (2003)
San Pedro Nodón and San Pedro Jocotipac	1,680	Cardonal with *Mitrocereus fulviceps,* or *Cephalocereus columna–trajani, Quercus* forest, Palmar with *Brahea dulcis*, riparian forest with *Taxodium mucronatum*.	264	Mixteco	Echeverría-Ayala (2003)
Santiago Quiotepec	545	Jiotillal with *Escontria chiotilla*, Tetechera with *Neobuxbaumia tetetzo*, Cardonal with *Pachycereus weberi*, riparian forest with *Salix chilensis*	252	Mestizo	Pérez-Negrón and Casas (2007)

Table 1. (Continued).

Sites or Regions	Altitude (in meters)	Vegetation	Ethnofloristic Richness	Human Group	References
San Lorenzo Pápalo	1,800	Deciduous tropical forest, *Quercus* and *Quercus–Pinus* forest, *Alnus* forest, and riparian forest.	367	Cuicateco	Solís (2006)
San Luis Atolotitlán	1,900	Chichipera, Cardonal dominated by *Mitrocereus fulviceps*, Izotal with *Beaucarnea purpusii*, rossette–scrub forest with *Dasylirion serratifolium*, *Quercus* forest, Palmar with *Brahea dulcis*.	280	Mestizo	Torres (2004)

Results

The Useful Flora of the Tehuacán–Cuicatlán Valley

The ethnofloristic inventory reported a total of 1,605 useful vascular plant species belonging to 671 genera and 147 families. The entire inventory is available as an electronic Appendix of this publication and can be consulted by contacting the authors. The comparison of these ciphers with those reported for other areas of Mexico highlights the importance of the Tehuacán Valley as the region with the highest absolute richness of useful plant species and one of the highest relative richness in relation to other areas, second only to the Sierra de Manantlán, Jalisco (Table 2). The inventory identified a total of 33 use categories of plant species, which contribute to satisfy a broad spectrum of human needs (Table 3). Based on the number of species belonging to each use category, the most outstanding uses are fodder, medicinal, food, firewood, ornamental, as well as wood and construction material.

Relative Importance of the Plant Groups

The most important plant families according to their general species richness in the region are Poaceae, Asteraceae, Fabaceae, Cactaceae, and Mimosaceae (Table 4), which are also important physiognomic elements of the plant communities of the area. The residual values revealed that the richest plant families in useful species are Poaceae, Asteraceae, Cactaceae, Cyperaceae, Mimosaceae, and Solanaceae; as mentioned, most of them have a high general floristic richness. However, in the valley there are some other families that also have high floristic richness, such as Fabaceae and Euphorbiaceae; they are not as proportionally important as sources of useful plants (Table 5).

Analyzing the data according to the use categories, the results indicate that certain families are sources of specific resources (see Table 6). For instance, among the plants that are used as fodder, the Poaceae and Cyperaceae are the most demanded groups, and practically all of their species are utilized for this purpose. In contrast, other families with high floristic richness, such as Asteraceae, Fabaceae, Euphorbiaceae, and Solanaceae, are the least used in this category. Among the ornamental plants, three of the most diverse plant groups (Asteraceae, Cactaceae, and Solanaceae) and three of the least rich (Crassulaceae,

Table 2. Relative richness of the useful species of the Tehuacán–Cuicatlán Valley, compared to other regions of Mexico.

Region	Useful Species	Area (km^2)	Relative Richness[1]	Reference
Valle de Tehuacán, Oaxaca and Puebla	1,605	10,000	0.16	This study
Sierra Norte de Puebla, Puebla	720	13,000	0.06	Martínez-Alfaro et al. (1995)
Uxpanapa, Veracruz	325	5,000	0.07	Toledo et al. (1995)
Selva Lacandona, Chiapas	415	13,000	0.03	Toledo et al. (1995)
Sian Ka'an, Quintana Roo	316	5,280	0.06	Toledo et al. (1995)
Huasteca, San Luis Potosí	445	–	–	Alcorn (1984)
Tepehuan region, Chihuahua	380	10,500	0.04	Pennington (1969)
Sierra de Manantlán, Jalisco	650	1,400	0.46	Benz et al. (1994)
Tzeltal region of Tenejapa, Chiapas	645	–	–	Berlin et al. (1974)
Península de Yucatán	1,000	140,056	0.01	Flores (1999)
Region de La Montaña, Guerrero	430	11,000	0.04	Casas et al. (1994)

[1] Estimated as a ratio among useful species and area of the region.

Convolvulaceae, and Malvaceae) showed high residual values. We found contrasting results in the case of species used as wood and construction material, among which Fagaceae and Mimosaceae had higher residual values than Asteraceae and Poaceae, which are two of the richest plant families in the valley.

The analysis allows appreciation of the relevant sources of human food plant families that are relatively well represented in the region, such as Cactaceae, Mimosaceae, Fabaceae, and Solanaceae. This is also the case of Cucurbitaceae, which, although is not one of the richest families of the region, it is recognized as an important source of edible plants. The highest residual values of species used as firewood were recorded for Mimosaceae and Fagaceae, whereas other floristically richer families had lower (Asteraceae and Cactaceae) or negative residual values (Poaceae and Euphorbiaceae). Finally, among the medicinal plants, Asteraceae is the family with the highest residual value, followed by other 10 families with markedly lower residual values. It is important to note that these families constitute a mixture of plant groups including well–represented families in the Tehuacán–Cuicatlán flora, such as Euphorbiaceae and Lamiaceae, as well as other less diverse families, such as Burseraceae, Fagaceae, and Cucurbitaceae. Other rich plant families of the region, such as Poaceae, Fabaceae, and Cactaceae, had low residual values, indicating that they are not primary sources of medicinal plants.

Use and Management of Plant Resources

A total of 1,011 species had a unique category of use, whereas the remaining 594 (37%) had two or, in the case of 147 species, more than four use categories (Table 7). Ethnobotanical studies reveal that the local people in the region actively manage their plant resources, using practices directed to maintain their availability or even increasing their amounts and/or improving their quality. Nearly 1,335 of the 1,605 useful species are gathered in the wild, but many of them are also submitted to some of the following forms of management: (1) Selective tolerance (62 spp.), through which people deliberately leave individual plants of particular species and sometimes particular phenotypes of these species in sites where the ecosystem is being perturbed; (2) protection (34 spp.), through which people undertake periodic prunings, remove plants that compete with them, protect them from herbivores, frosting, and other factors; (3) enhancement (40 spp. by transplanting vegetative parts and 10 through their sexual propagules), through which people promote the dispersion of sexual and vegetative propagules to expand their availability and/or phenotype transplantation (people remove some complete individuals from their natural site to other locations), or even the cultivation of the latter ones. Finally, 358 species are cultivated in different agricultural systems, with the highest diversity found in home gardens. Examples of plant species submitted to one or more management forms are presented in Table 8.

Discussion

To date, the richness of useful plant species recorded in the Tehuacán Valley represents

Table 3. Categories of use of the useful flora of the Tehuacán–Cuicatlán Valley and the species number represented in each category.

Uses	Number of Species
Fodder	874
Medicinal	396
Food	339
Ornamental	313
Firewood	209
Wood and Construction Materials	129
Living Fences	53
Soils Control	51
Ceremonial	50
Handicraft	47
Shade	41
Toxic / Poisons	26
Resins / Latex	22
Domestic Tools	17
Fibers	17
Sources of Saponins	15
Alcoholic Beverages	14
Glues	12
Dyes	9
Commercial	9
Spices	9
Stimulants	9
Toys	8
Insecticide	7
Aromatizing	4
Edible Worms Habitat	3
Food Preservative	3
Ferments	2
Industrial	2
Beverage	1
Cosmetic	1

61.2% of the total plant species richness, 75.3% of the genera, and 81.6% of the families recorded in the vascular flora of the region by Dávila et al. (2002) and Mendez-Larios et al. (2004, 2005). The 1,605 useful plant species reported here represent nearly 23% of the 7,000 useful vascular plant species probably existing in Mexico according to estimates by Caballero (1984) and Caballero et al. (1998). This information indicates that the Tehuacán–Cuicatlán Valley is Mexico's richest area of ethnobotanical knowledge documented up to now. This fact is particularly relevant since this knowledge is found in a relatively small area (nearly 10,000 km^2). Such important information is known in part because of the effort of ethnobotanical research invested in the area, but mostly because of the natural biological diversity characterizing the region (Dávila et al. 2002) as well as its cultural richness (Casas et al. 2001) and history (MacNeish 1967).

The diversified pattern of plant uses, in terms of the number of species and the number of uses per species, coincides with the information generally documented in ethnobotanical studies in Mexico (Berlin et al. 1974; Zizumbo-Villarreal and Colunga-García-Marín 1982; Alcorn 1984; Caballero and Mapes 1985; Bye 1993; Benz et al. 1994; Martínez-Alfaro et al. 1995; Casas et al. 1994, 1996, 2001; Caballero et al. 2000; Lira 2004). This diversified pattern has been considered as a part of what Toledo et al. (2003) called the multiple use of natural resources, characteristic of the form of subsistence of Mesoamerican indigenous rural peoples. The analysis of the spatial distribution of the plant resources and their association with particular ecosystems is yet to be performed, but some attempts to analyze data in this direction (Solís 2006), as well as ecological studies conducted in the area demonstrating the occurrence of high β diversity (Osorio-Beristain et al. 1996; Valiente-Banuet et al. 2000), suggest that ecosystems are reservoirs of particular types of resources and that both the diversity of plant resources and ecosystems are relevant to analyze the pattern of multiple uses of resources and environment of human subsistence in the rural areas of the region.

The residual analysis does not generally corroborate the null hypothesis that families with a higher number of useful species would be those having the higher general species richness. The hypothesis was correct for some families, such as Asteraceae, which contributes a high number of medicinal plant species, but this is not the case for most families. This pattern corroborates that humans have directed their attention to groups with particular qualities of plant resources, rather than to the most abundant or diverse elements of nature (Moerman and Estabrook 2003; Hernández-Delgado et al. 2003, 2005; Caballero et al. 2004; Moerman 2005; Canales et al. 2005, 2006).

The Tehuacán–Cuicatlán Valley has a rich and well–documented history of plant management (MacNeish 1967, 1992; Smith 1967). It is one of the areas widely recognized for the studies on prehistory documenting the origins of agriculture in the New World. Its dry conditions were a determinant in the preservation of signs of early processes of interactions between humans and plants. But the present information suggests that

Table 4. The most important plant families in the Tehuacán–Cuicatlán Valley, according to their richness of useful species, in the higher categories of use.

Family	Total species in the Tehuacán –Cuicatlán Valley (from Dávila et al. 1993)	Useful Species	% Useful Flora	Fodder	Food	Firewood	Medicinal	Ornamental	Wood and Construction Materials
Poaceae	220	220	100	219	12	1	15	7	4
Asteraceae	345	195	57	115	23	9	83	34	1
Fabaceae	191	80	42	56	20	5	19	4	3
Cactaceae	74	67	91	40	44	16	7	16	9
Mimosaceae	72	61	85	49	31	39	13	5	19
Cyperaceae	42	42	100	42	1	0	4	0	0
Euphorbiaceae	106	38	36	16	9	1	19	6	2
Solanaceae	76	52	68	16	14	0	19	12	0
Fagaceae	25	33	132	9	4	33	5	1	32
Malvaceae	56	25	45	16	3	1	9	8	0
Caesalpinaceae	34	22	65	17	0	10	6	3	4
Bromeliaceae	47	24	51	20	2	1	4	5	0
Cucurbitaceae	21	20	95	8	12	0	4	1	0
Lamiaceae	95	31	33	11	4	0	20	5	0
Verbenaceae	43	16	37	9	8	0	12	3	0
Crassulaceae	49	30	61	2	0	0	6	26	0
Burseraceae	19	20	105	5	0	14	6	0	4

Table 5. Residual values obtained for the most important useful plant families in the Tehuacán–Cuicatlán Valley.

Family	Total Species	Useful Species	Calculated	Residual
Poaceae	220	220	105.6498	118.3502
Asteraceae	345	195	161.0373	33.9627
Fabaceae	191	80	92.7999	−12.7999
Cactaceae	74	67	40.9572	26.0428
Mimosaceae	72	61	40.071	20.929
Cyperaceae	42	42	26.778	26.222
Euphorbiaceae	106	38	55.1364	−17.1364
Solanaceae	76	52	41.8434	10.1566
Fagaceae	25	33	19.2453	13.7547
Malvaceae	56	25	32.9814	−7.9814
Caesalpinaceae	34	22	23.2332	−1.2332
Bromeliaceae	47	24	28.9935	−4.9935
Cucurbitaceae	21	20	17.4729	2.5271
Lamiaceae	95	31	50.2623	−19.2623
Verbenaceae	43	16	27.2211	−11.2211
Crassulaceae	49	30	29.8797	0.1203
Burseraceae	19	20	16.5867	3.4133
Acanthaceae	35	22	23.6763	−1.6763
Convolvulaceae	38	20	25.0056	−5.0056
Agavaceae	25	17	19.2453	−2.2453

the importance of the Tehuacán Valley is not a question of whether there are appropriate environmental conditions for good preservation of archaeological remains; rather, it appears that the signs found are a representation of intense processes occurring in a fascinating region characterized by high biological diversity and culture whose expression is maintained to the present day.

Table 6. Residual values obtained for the plant families from the Tehuacán–Cuicatlán Valley in the most important categories of use.

Family	Fodder	Ornamental	Wood and Construction Materials	Food	Firewood	Medicinal
Poaceae	137.5486	−5.6876	0.8737	−5.2285	−4.571	−12.4976
Asteraceae	−13.4139	17.0499	0.6862	−0.2785	6.8165	40.4774
Fabaceae	−14.5561	−7.6987	−0.7788	4.1751	−1.3569	−5.0118
Cactaceae	13.4008	8.291	2.5887	33.8379	6.4724	−2.9484
Mimosaceae	23.1522	−2.6408	12.5437	20.9347	29.4182	3.292
Cyperaceae	36.4232	–	–	−7.6133	–	−2.102
Euphorbiaceae	−22.6216	−2.8002	−3.6913	−2.7109	−7.6604	5.2052
Solanaceae	−11.3506	4.2228	–	3.7411	–	8.8112
Fagaceae	0.8101	−5.0381	24.4862	−3.7905	22.1445	0.9414
Malvaceae	−3.8366	0.9048	–	−6.2909	−9.0154	1.2152
Caesalpinaceae	5.4288	−3.345	−3.3113	–	−0.6116	0.8596
Bromeliaceae	3.5447	−1.7883	–	−6.8553	−9.2593	−2.703
Cucurbitaceae	1.3129	−4.9017	–	4.4031	–	0.4222
Lamiaceae	−23.4889	−3.4251	–	−7.1785	–	7.5274
Verbenaceae	−5.9525	−3.6519	–	−0.6617	–	5.7778
Crassulaceae	−15.2067	19.1435	–	–	–	−0.9434
Burseraceae	−0.9357	–	−3.6488	–	2.9819	2.6626
Acanthaceae	4.0531	−2.3791	–	–	–	−1.2606
Convolvulaceae	−1.074	2.5186	−6.2213	−4.4197	−8.5032	2.3788
Agavaceae	−6.1899	−1.0381	−5.5138	2.2095	−4.8555	−2.0586

Table 7. EXAMPLES OF PLANT SPECIES WITH MORE THAN THREE USES IN THE TEHUACÁN–CUICATLÁN VALLEY.

Species	Family	Uses Number	Uses
Guazuma ulmifolia	Sterculiaceae	11	Fodder, firewood, food, medicinal, wood and construction materials, ornamental, living fence, fibers, handicrafts, ceremonial, shed
Acacia farnesiana	Mimosaceae	10	Fodder, firewood, medicinal, wood and construction materials, ornamental, living fence, handicrafts, soils control, aromatizing
Alnus acuminata	Betulaceae	9	Fodder, firewood, medicinal, wood and construction materials, ornamental, handicrafts, shed, soils control, colorant
Agave atrovirens	Agavaceae	8	Firewood, medicinal, living fence, fibers, alcoholic beverage, stimulant, source of soap, soils control
Bursera morelensis	Burseraceae	7	Fodder, firewood, wood and construction materials, living fence, resins / latex, soils control, colorant
Stenocereus stellatus	Cactaceae	7	Fodder, firewood, food, wood and construction materials, living fence, alcoholic beverage
Nopalea cochenillifera	Cactaceae	6	Fodder, food, medicinal, ornamental, handicrafts, colorant
Fouquieria formosa	Fouquieriaceae	5	Fodder, firewood, medicinal, wood and construction materials, shed
Fraxinus uhdei	Oleaceae	5	Firewood, medicinal, wood and construction materials, ornamental, shed
Pachycereus hollianus	Cactaceae	4	Firewood, food, wood and construction materials, living fence
Polaskia chende	Cactaceae	4	Fodder, food, living fence, soils control
Polaskia chichipe	Cactaceae	4	Fodder, food, living fence, soils control

The results of this study illustrate that the old interrelationships between the people and plants of the Tehuacán Valley are ongoing. Most of the plant resources are wild and most of them are obtained by gathering. But recent studies reveal that gathering is not a simple, uniform way of harvesting nature (i.e., see the studies by Arellano and Casas (2003) with *Escontria chiotilla*; González-Soberanis and Casas (2004) with *Sideroxylon palmeri*; Blancas (2007) with *Myrtillocactus schenckii*; and Delgado (2008) with *Agave potatorum*). Gathering involves different techniques and is conducted at different intensities according to a number of social, economic, and cultural factors (González-Insuasti and Caballero 2007; Casas et al. 2008). Currently, people undertake strategies and make agreements in their communities to carry out different routines for gathering and extracting plant resources for a number of purposes (Casas et al. 2008). In relation to the risks caused by the extraction and use of plant resources, these processes constitute a route of research particularly relevant to understanding the early processes of plant management and their relation to the origins of plant domestication (Casas et al. 2007).

Of particular relevance is the information that nearly 500 plant species receive some management type (both silvicultural *in situ* management and/or cultivation). Some studies have documented that these practices may cause modifications in frequencies of phenotypes in the populations of some species and, in some cases, an increase in the frequency of desired phenotypes, as well as morphological differentiation and changes in physiology and life cycles of the managed populations and wild populations (Casas et al. 2007). Accordingly, this group of plants deserves deeper ecological and evolutionary study since the ethnobotanical studies have documented only collaterally the occurrence of such processes.

Table 8. Examples of plant species submitted to one or more management forms in the Tehuacán–Cuicatlán Valley.

Family	Species	Management Forms
Agavaceae	*Agave peacockii*	Tolerated, cultivated
Agavaceae	*Agave potatorum*	Tolerated, cultivated, enhanced
Asteraceae	*Montanoa tomentosa*	Tolerated
Cactaceae	*Myrtillocactus schenckii*	Tolerated, cultivated
Cactaceae	*Myrtillocactus geometrizans*	Tolerated, cultivated
Cactaceae	*Pachycereus hollianus*	Tolerated, cultivated
Cactaceae	*Polaskia chende*	Tolerated, cultivated
Cactaceae	*Polaskia chichipe*	Tolerated, cultivated
Cactaceae	*Stenocereus stellatus*	Tolerated, protected, cultivated
Cactaceae	*Stenocereus pruinosus*	Tolerated, protected, cultivated
Cucurbitaceae	*Sicyos parviflorus*	Tolerated, protected
Chenopodiaceae	*Chenopodium ambrosioides*	Tolerated, enhanced
Fagaceae	*Quercus glaucoides*	Tolerated, protected
Julianaceae	*Juliana adstringens*	Tolerated, protected
Malvaceae	*Anoda cristata*	Tolerated, transplanted
Mimosaceae	*Leucaena esculenta*	Tolerated, protected, transplanted
Sapotaceae	*Sideroxylon palmeri*	Tolerated, cultivated

Management processes are ongoing, and the plant species that are managed are the expression of resources with a particular cultural value on which people are practicing forms of procurement. Recent studies have documented that some of these management practices have had some effect on the populations of various species, which can be interpreted as forms of incipient domestication. Among these species are the columnar cacti *Escontria chiotilla, Pachycereus hollianus, Polaskia chende, P. chichipe, Stenocereus stellatus*, *S. pruinosus* (Casas et al. 1997b, 1999b, 1999c; Cruz and Casas 2002; Arellano and Casas 2003; Otero-Arnaíz et al. 2003, 2005a, 2005b; Carmona and Casas 2005; Tinoco et al. 2005; Oaxaca-Villa et al. 2006; Rodríguez-Arévalo et al. 2006; Ruíz-Duran 2007), as well as species of other plant groups such as *Sideroxylon palmeri* (Sapotaceae) (González-Soberanis and Casas 2004), *Ceiba aesculifolia* ssp. *parvifolia* (Bombacaceae) (Avendaño et al. 2006), and *Proboscidea louisianica* spp. *fragans* (Pedaliaceae) (Paredes-Flores 2006). In all these studies, the plant uses, their variations, and other aspects related to their biology have been documented and analyzed within the context of domestication by means of the *in situ* management of populations. These examples of *in situ* management represent a particular management intensity of plant resources, in which domestication appears to be occurring, and therefore their study could help in understanding more about processes leading to the origins of agriculture and domestication of plants in a symbolic region for this type of study.

This information, however, is not only important from a theoretical point of view. Such high richness of knowledge and management techniques can be particularly valuable for developing strategies of sustainable management of plant resources. The Tehuacán Valley is a biosphere reserve, and people inhabiting the area live with the particular problems of poverty and scarcity of opportunities to develop their traditional production systems (Valiente-Banuet et al. 2006). The authorities of the reserve, the local people, and the scientists are now in the process of constructing a management plan of the protected area, including the core and buffer zones. The information accumulated through our studies is undoubtedly crucial for recovering traditional practices and designing new ones before the also–new challenges of sustainable forms of using natural resources will take place.

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