Cuicatec Ethnobotany: Plants and Subsistence in San Lorenzo Pápalo, Oaxaca

Leonor Solís and Alejandro Casas

Abstract

An ethnoecological approach was conducted to identify the role of plants and animals in subsistence of the Cuicatec people. The study was carried out in the indigenous community of San Lorenzo Pápalo, Oaxaca, where we documented and analyzed local people's knowledge about plants and animals and their local uses and management. This chapter focuses on the ethnobotanical research, while the study of interactions with fauna was published elsewhere. We interviewed 30 persons who are the heads of nearly 20% of the households of the community. All of them are Cuicatec speakers, and some are bilingual (Cuicatec and Spanish). An inventory of plants, their uses, frequency, and quantities extracted and consumed to satisfy different needs (mainly food, medicine, firewood, construction, and ornamentation) was documented, as well as the species preferred for those uses; then, based on the local nomenclature, we analyzed the Cuicatec folk classification of plants which was corroborated in the field. We explored the local perception of the territory and landscape, identifying 12 environmental units classified based on vegetation types and different anthropogenic areas. In those units we carried out ecological vegetation sampling, analyzing the distribution and abundance of useful plants as main indicators of their spatial availability, the species richness and diversity, and the relative ecological importance index of each species, according to their density, frequency and biomass in the sampling units. In addition, we documented the local knowledge about seasonal availability of useful products. With this information we examined possible risks over some species and potentialities of using different plant resources. A total of 520 plant species were recorded, 367 having one or more uses, 176 are fodder, 84 are edible plants, 73 medicines, and 47 are appreciated as ornamental plants, among other

L. Solís · A. Casas (✉)
Instituto de Investigaciones en Ecosistemas y Sustentabilidad, Universidad Nacional Autónoma de México, Morelia, Michoacán, Mexico
e-mail: lsolis@cieco.unam.mx; acasas@iies.unam.mx

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use types. We determined the human cultural importance of plant species through free listing techniques and then evaluated their extraction rates. Nearly 98.4% of plant species showed a restricted distribution through different vegetation types. Every type of vegetation provides differential diversity and products biomass. For instance, tropical deciduous forests and riparian vegetation are diverse, supplying different types of food, medicinal, ornamental plants, and fodder, whereas the coniferous and oak forests are main sources of fuelwood and materials for construction. It is remarkable that anthropogenic areas like crop fields, fallow agricultural areas, homegardens, and even the secondary vegetation are outstanding sources of some of the most important resources like edible and medicinal plants. In general, extraction rates of plant resources are low in relation to their spatial availability, except for the most important fuelwood species (*Quercus conzatii* and *Quercus magnolifolia*, among others), which are extracted at high rates and can be identified as species in risk that deserve regulations and particular studies to recommend sustainable forms of extraction. Biocultural, ecological, and ethnobiological studies may substantially contribute social and ecological information for constructing regulation systems by local decision makers.

Introduction

It is widely recognized the important role of non-timber forest products in traditional people's life (Casas et al. 1994; Cunningham 2001; Tuxill and Nabhan 2001; Blancas et al. 2013; Rangel-Landa et al. 2016; Solís and Casas 2019; Zarazúa-Carbajal et al. 2020), since rural households commonly practice a subsistence pattern based on a broad spectrum of activities and resources like agriculture, livestock, hunting, and gathering of forest products (Toledo 1990; Cavendish 2001; Casas et al. 1994; Lotero et al. 2022). In Mexico, forest products are mostly goods of common access that provide multiple satisfiers to people's life (Epstein et al. 2021). These are collected in wild ecosystems, but some of them are also silvicultural managed and/or cultivated in agricultural plots, homegardens, and secondary vegetation (Blancas et al. 2010; Casas et al. 1996, 1997, 2017; Ford and Nigh 2015; Clement et al. 2021).

Gathering and management practices are expressions of ancient interactions between humans and plants, which have generated knowledge and techniques throughout time (Cavendish 2001, Toledo and Barrera Bassols 2008; Casas et al. 2016). Traditional gathering is generally a low-impact practice not causing drastic changes on ecosystems. But in some cases, the products extraction overpasses certain thresholds determining significant changes and drastic degradation of systems (Torres-García et al. 2015, 2020). Such processes are commonly associated to economic and sociocultural changes related to the transitions to market economy, which abruptly affect traditional rural life (Salisbury 1970; Casas et al. 1994; Gómez-Baggethun et al. 2010). Identifying such thresholds and causes of pressures on ecosystems is a main challenge of both academic and management sectors (Torres-García et al. 2013). Even more, the effects of disturbance over population of a species commonly have consequences on populations of other species (Valiente-Banuet et al. 2015). Therefore, sustainable perspectives of using ecosystems should consider how use and management affect whole systems, not only particular components. But in such context, the diversified patterns of using resources and ecosystems, a common traditional practice among indigenous rural communities, provide good principles that appear to be effective to buffer the degradation of both ecosystems and their components. We documented in this chapter the subsistence patterns of the Cuicatec people in a community of the Tehuacán-Cuicatlán Valley to analyze the role of plant species on their life, how the traditional use and management processes involve the diversity of components and ecosystems, the effectiveness or not of their management for sustainability, and how these management patterns are affected by external factors.

The Tehuacán-Cuicatlán Valley is one of the main reservoirs of biodiversity of the arid and semiarid environments of Mexico (Dávila et al. 2002), harboring more than 3,000 species of vascular plants, distributed in 29 vegetation types (Valiente-Banuet et al. 2009). Casas et al. (2001, 2017), Lira et al. (2009), and Blancas et al. (2010) documented in the region more than 2,000 species of plants used by local peoples, which makes the Tehuacan-Cuicatlán Valley the richest ethnobotanical inventoried region in Mexico. The Nahua, Popoloca, Chocho, Mazatec, Chinantec, Mixtec, Ixcatec, and Cuicatec live in this region, being nearly 30% of the total population. The Ixcatec and Cuicatec are human cultures exclusive to the region (Casas et al. 2001). All of them have deep ethnobotanical knowledge resulting from a cultural history of more than 10,000 years old (MacNeish 1967, 1992).

San Lorenzo Pápalo is a Cuicatec rural community with a history of nearly 750 years (Doesburg 2001a) and clear features of a subsistence economy based on agriculture of maize, beans, and squashes, free raising of livestock (the last five centuries), and multiple use of forest resources. Such long history allows supposing that the traditional practices of using local resources have strong bases of sustainability. This study explores this supposition by documenting the Cuicatec knowledge of plant resources and their role in people's subsistence.

Previous ecological studies in the region showed high α and β diversity among plant communities (Osorio et al. 1996; Dávila et al. 2002; Valiente-Banuet et al. 2009); we therefore expected that the distribution of most plant resources would be rather restricted, a fact that would enhance the ecological complementarity of resources provision. We looked for analyzing sustainable management strategies by examining the general landscape management rather than sustainable harvest of particular resources. Such an approach should be based on information on distribution, abundance, richness, and diversity of plant resources in the different types of forests and comparing such information with their use rates. This would allow us to identify the risks for the permanence of some species under current management patterns, as well as to analyze the potential use of other resources and the opportunities to manage species richness under principles of ecological complementarity. We therefore emphasized the importance of joining ethnobotanical and community ecology approaches to understand the bases of local sustainable management.

According to previous information: (1) San Lorenzo Pápalo has been using a broad spectrum of forest resources to complement agriculture probably for thousands of years, and livestock for five centuries (Solís 2006; Solís and Casas 2019). However, ethnobotanical studies in the region have found that, more commonly, a reduced number of species is the most used to satisfy the households' needs (Casas et al. 2008, Blancas et al. 2010; Rangel-Landa et al. 2016). We consequently expected to find this pattern in the community studied and, therefore, high pressures on the group of more used species, particularly those that are scarce or with narrow distribution. (2) The diversity of resources allows buffering pressures on the most used plant species, and this pattern supports the premise that the multiple use of resources (Toledo et al. 1976) is the base of the rationality of sustainable use patterns. For the contrary, excessive practices directed to few resources would be less sustainable. (3) The high β diversity characterizing plant communities of the region makes feasible to expect high specificity in the availability of plant resources and, therefore, the complementarity of environmental units strongly supports sustainability of plant resources management at landscape level.

This chapter aims to document the Cuicatec knowledge of plants, their nomenclature and classification, and use and management by people of San Lorenzo Pápalo. We looked for identifying the resources with higher cultural importance, analyzing their spatial and temporal availability compared with their use and extraction rates. We particularly directed our effort to: (1) complete an inventory of the plants locally used, their Cuicatec names and classification, their use and management forms; (2) determine the cultural importance of plant species to satisfy different human needs, compared with those products obtained from agriculture and livestock raising, and the rates of use and extraction from the forest and other anthropogenic areas; (3) describe the distribution, abundance and temporal availability of plant resources in different ecosystems of the territory of San Lorenzo Pápalo; and (4) analyze risk and potential sustainable use forms of the most important species.

The Cuicatec

Ethnographic and ethnobiological studies of the Cuicatec (Starr 1902; Belmar 1902; Elfego 1922; Basauri 1940; De la Cerda 1942; Weitlaner 1969; Bazúa 1982; Hunt 1972; Geist 1997; Solís 2006; Solís and Casas 2019) indicate that these people live in a restricted area of the Sierra of the Pápalos, at north and northeast of the state of Oaxaca, including the villages of Concepción Pápalo, Santos Reyes Pápalo, Santa María Pápalo, San Lorenzo Pápalo, and Teutila (Fig. 1). It is a territory 8,400 km^2 extent, characterized by a highly heterogeneous orography with elevations between 600 to 3,300 m, and numerous rivers among them the Grande, Sendo, Cacahuatán, and Chiquito.

The territory has three well-differentiated climates, one cold, humid, or dry, in the highlands of the Sierras of Teutila and Pápalos; another temperate in the area between the Pápalos and the Santo Domingo River, with pine-oak forests in higher altitudes and tropical dry forest in the lowlands, and a third warm, humid, or dry, in Cuicatlán and Quiotepec, where vegetation is dominated by columnar cacti and tropical wet and dry forests (Valiente-Banuet et al. 2009).

The presence of the Nahua people is relatively recent in the region, but the older native people, descendant from prehistoric human groups of the Tehuacán-Cuicatlán

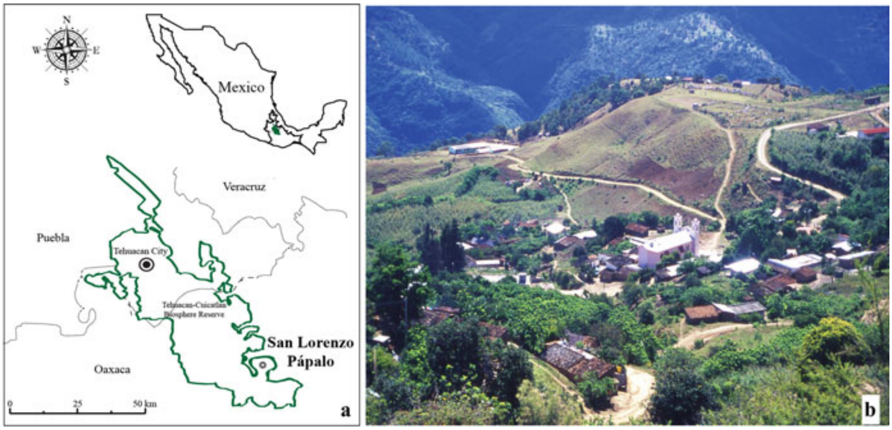

Fig. 1 Study area. (**a**) Location of the community of San Lorenzo Pápalo, Oaxaca in the south-eastern area of the Tehuacán-Cuicatlán Valley, central Mexico, (**b**) a general view of the village

Valley, belong to two linguistic families of the Otomanguean group: the Popolocana (from which the Popoloca, Chocho, Ixcatec, and Mazateco derived), and the Mixtecana (from which the Triqui, Mixtec, and Cuicatec derived) (De Ávila 2004, 2010). According to Kauffman (1990), the Proto-Otomanguean language divided into the two main branches approximately 6,000 years ago. The family Mixtecana, according to De Ávila (2004, 2010) in turn divided into the Proto-Triqui of the subfamily Mixteco-Cuicateca 3,700 years ago, and the Proto-Cuicatec became differentiated from the Mixtec 2,500 years ago. Eberhard et al. (2022) distinguish two Cuicatec languages, one from Tepeuxila with approximately 8,600 speakers, including San Lorenzo Pápalo, and the other from Teutila with nearly 3,000 speakers, and a total of about 13,000 Cuicatec speakers.

During the Classic period (2,100 to 700 years ago) settlements of the region became villages and their ceremonial centers were established in the tops of hills (Byers 1967), when the population of the Tehuacán Valley was approximately 20,000 to 30,000 people (Doesburg 2001a). By that time the Cuicatlán region was under the power of the great cities of Monte Albán and Huajuapan, while southern Puebla, including areas of the Tehuacán Valley, was dominated by Teotihuacán and Cholula (Doesburg 2001a). The Classic period ended with the partial abandonment of Monte Albán and Teotihuacán in the eighth century. Then, the Postclassic period lasted until the arrival of the Spaniards in 1519 (Byers 1967).

By the end of the Classic period (about the year 1000 AC), all irrigable land of the area was already in use. Remains of irrigation channels show the intensive agriculture practiced in the area. During the Postclassic, the Cañada of Cuicatlán region had a high population growth and intensive use of land and water, and the chiefdoms became small states. About 1200 to 1520 AC, numerous villages settled on small hills in the Sierra, which persisted until the Spanish conquest (Doesburg 2001a). The main Cuicatec manors were Cuicatlán, Alpitazagua, and Quiotepec (Geist 1997).

The Cuicatec were independent until 1460, when they became dominated by the Aztec (Doesburg 2001b). The Geographic Relations of the sixteenth century refer to that these areas paid tribute to the Mexica (Geist 1997), while in the Mendocino Codex, Cuicatlán appears as tributary to the Aztec (Geist 1997). Hunt (1972) described the Cuicatec societies of the fifteenth and sixteenth centuries, demonstrating that the geographic distribution of the villages was strongly determined by the presence of water bodies, small streams tributaries of the Grande River. According to this author, the Cuicatec villages of the lowlands were small territories highly populated depending on irrigation, while settlements in the Sierra were spread, low-populated, depending on subsistence agriculture mostly seasonal and small irrigated areas (Hunt 1972; Doesburg 2001a), a pattern that is similar to what can be seen at present in San Lorenzo Pápalo. According to Doesburg (2001a), after the conquest, the indigenous chiefdoms were the base of the Spanish administration and, since the sixteenth century, San Lorenzo Pápalo appears as a village subject to the Spanish Crown.

During the Colonial period and until the nineteenth century, the ancient Cuicatec chiefdoms maintained certain legitimacy owning lands, based on documents of the colonial period (Doesburg 2001a). But these lands were then opened to the market and the owners forced to sell them to Mexican and stranger great investors, causing the disintegration of the old Cuicatec chiefdoms about 1870, when vast extensions of land were used for establishing estates, mines, and coffee plantations (Doesburg 2001a).

During the twentieth century several processes intensified the integration to the Mexican schemes of development. It is pertinent to mention two facts, the violent, discriminatory assimilation to educational programs directed to eliminate indigenous languages, and the establishing of a net of roads connecting the villages with the railways and highways in the 1960s. Doesburg (2001a) described that the first fact, by the mid- twentieth century, limited the teaching of Cuicatec to the children in schools and homes, while Geist (1997) referred to that the second fact favored the connection of the region with companies and markets that took advantage of the integration and changed the economic, social, and cultural relations with the country (Geist 1997). Bazúa (1982) documented a third important fact; by the 1970s the exploitation of forests was a dynamic economic activity in the region, but it was concessioned to the company "Papelera Tuxtepec S. A." The incomes of local people derived from this concession were very low, nearly 70% of them were destined to communitarian constructions, and 30% to households' incomes. People decided interrupting these concessions by the 1990s.

The Community Studied: San Lorenzo Pápalo

San Lorenzo Pápalo is at the northeast of the state of Oaxaca, in the Sierra of the Pápalos, at an elevation of 1,800 m (Fig. 1). The territory of the community is 3,900 ha, belonging to the municipality of Concepción Pápalo. It is a mountainous territory with elevations between 1,500 and 3,000 m, with heterogeneous physiography and diversity of climates and vegetation types. Climate is predominantly temperate, but part of the territory are lowlands with tropical dry forest, while the highlands are colder than the area where the village is settled. The main rivers are the Grande and Sendo, tributaries of the Papaloapan River. The main vegetation types are a variety of pine-oak forests, *Alnus* forests, tropical deciduous and riparian vegetation.

The Cuicatec classify their territory into "warm land" (***yo ino***) and "cold land" (***ji quió***), which generally correspond to tropical dry and temperate forests, respectively. The natural forests are called the "monte" (***bo'cheno*** in Cuicatec), a term used to classify the vegetation types. For instance, the *Alnus* forest is called "***cheno ya'a ni***," pine forest "***cheno ya'a ca***," and oak forest "***cheno ya'a ja'a***." People recognize geomorphological units like hills "***d'u tu***," rocky areas "***y'a ba***," hills "***ti cu***," and mountains "***ti clun***." The piedmont is called "***coó jiquió***," and valleys "***y'u du***," the rivers "***jicu***," and gullies "***ya'a***."

People from San Lorenzo Pápalo migrate, our survey allowed registering that nearly 50% of people interviewed had at least one relative working outside, mostly (61.11%) in Mexico City, 27.7% in the city of Puebla, and 11.1% in the city of Oaxaca. Approximately 73.3% of migrants send money to their families, but it happens irregularly. Therefore, the main economic activity continues being agriculture, with products mainly destined to consumption by households and partly to interchange. The main production system is the milpa, called ***ñango'o***, which is classified into different types using the prefix ***dat***. The Cuicatec name the irrigated milpa as ***dat ió***, the seasonal milpa as ***dat cubi*** and the seasonal milpa in the cold highlands as ***dat iquió***. The main crops are maize, beans, and squashes, mainly destined to the households' subsistence. For land tilling they use plough, or a stick called coa in Nahuatl and ***ya nda'a*** in Cuicatec, and most households apply chemical fertilizers. They recognize two general varieties of maize, one for warm land and the other for cold land (***nin jiquió*** and ***nin yo ino***, respectively), each general variety with white, yellow, or pinto more particular varieties. Local people use to cultivate "mosquito" beans (*Phaseolus vulgaris*) in the irrigated area, the "milpa beans" in the seasonal agricultural area and the "mayeso" beans (*Phaseolus coccineus*) in the cold land. The squashes cultivated are varieties from the species chompo (*Cucurbita mixta*), támala (*Cucurbita moschata*), chilacayota (*Cucurbita ficifolia*), and nahuayota (*Cucurbita pepo*). The commercial crops are granada (*Passiflora ligularis*), avocado (*Persea americana*), chirimoya (*Annona cherimola*), peach (*Prunus persica*), and chile canario (*Capsicum pubescens*).

Research Methods

Subsistence patterns. We conducted semi-structured, qualitative interviews, and questionnaires for a quantitative survey, to 20% of households (30 in total). We asked about cultivation techniques, amount of annual production and the relative importance in their economy. Also, we explored the role of homegardens and domestic animals in subsistence.

Inventory of useful plants. We collected and herborized plant specimens monthly throughout one year, obtaining ethnobotanical information showing the specimens to the local authorities of the Agencia Municipal and people of the community, who provided information about names, forms of use, and preparation. The information was systematized in the database "Ethnoflora of the Tehuacan Valley" at the CIEco, UNAM, designed following the format of the "Banco de Información Etnobotánica sobre Plantas Mexicanas" (BADEPLAM), of the Botanical Garden at UNAM, including geographic and ecological information, elevation, vegetation type, life form, taxonomic, and ethnobotanical information. The specimens collected were deposited at the National Herbarium MEXU.

Cuicatec nomenclature and classification. Our study documented the local nomenclature and classification of plants, as an approach to the local knowledge and perception of nature (Berlin 1992). We based our methods on generating lists of Cuicatec names, then exploring classification patterns, as suggested by De Ávila (2004). We firstly obtained the names of the collected specimens, then we analyzed nomenclatural patterns, which were finally corroborated in the field. We complemented the nomenclatural information obtained in the field with a dictionary Cuicatec-Spanish elaborated by Anderson and Concepción (1983), the names obtained from this source were also corroborated and, in some cases, corrected in the field. The information was compared with nomenclatural records documented among the Mixtec by Casas et al. (1994) and De Ávila (2004, 2010).

Cultural importance of species. We evaluated the cultural importance, or the value of plant species based on their role in the Cuicatec culture (Turner 1988; Stoffle et al. 1999; Pieroni 2001). Following Turner (1988), the more frequently and intensively used is a plant the higher is its cultural importance. Such importance may vary according to the quality of plant products, their use intensity, exclusiveness, among other attributes that in turn may change through time. Several approaches have been developed to identify the cultural importance of plants. Turner (1988), Stoffle et al. (1999), Parra et al. (2021), and other research groups have proposed indices to evaluate the cultural importance of species or varieties. In this study we followed the approach based of free listing (Frei et al. 1998; Turner 1988).

Based on 30 free lists, we identified the species with the highest cultural importance of the following use categories: (1) medicinal for gastrointestinal illnesses, (2) medicinal for respiratory ailments, (3) medicinal for muscular pain, (4) medicinal for cultural ailing like "limpias" (cleaning cure), "susto and espanto" (scare), and "mal de ojo" (evil eye), (5) fuelwood, (6) edible as green vegetables or "quelites," (7) edible fruits, (8) edible seeds, (9) edible roots, tubers, and bulbs, (10) edibles flowers, (11) ornamental, (12) construction, (13) fodder, (14) ritual use.

Amounts of plant products extracted. Through semi-structured interviews and a survey, we evaluated the amounts of plant products extracted from the most culturally important species identified. We obtained information from different measure units locally used, and then we transformed these units in kg or number of plant individuals; whenever possible, we directly weighted the products, we also documented the seasonal availability of products and frequency of extraction. For estimating the extraction and use of fuelwood, we weighted the amount consumed per day, we analyzed the composition of samples of fuelwood available in the homes studied, identifying most of the species, based on local names and features of wood and cortex, as well as the proportion of each species in the samples analyzed.

Distribution and abundance of useful plant products. Vegetation sampling was carried out in different environmental units to estimate density, frequency, and biomass of the species composing each unit type. We selected areas with different vegetation and anthropogenic unit types in: (1) tropical deciduous forest, (2) riparian vegetation, (3) *Alnus firmifolia* forest, (4) *Pinus michoacana–Quercus conzatii* forest, (5) *Pinus lawsonii–Quercus crassifolia* forest, (6) *Quercus rugosa* forest, (7) *Quercus laurina* forest, (8) *Quercus magnolifolia* forest, (9) granada (*Passiflora ligularis*) gardens, (10), homegardens, (11) irrigated milpas, and (12) seasonal cultivation milpas. In each unit we sampled at least two 500 m^2 squares, 50 m long per 10 m wide, divided in 10 m^2 subunits. In these squares we recorded all individuals of each species of trees and shrubs, thus estimating their density. Herbs were sampled through five 1 m^2 squares randomly placed within each 10 m^2 square estimating the percentage of area covered by each species. The frequency was calculated as the percentage of 10 m^2 squares in which a species was present. The biomass was calculated by measuring height, two perpendicular diameters and, in trees, the breast height diameter of trunks, then we used these measures to calculate the volume of individual plants approaching their forms to ellipsoids (shrubs) and to inverted cones (trees), and finally estimating the total volume per species in the sampling area. The relative value of ecological importance (REI) of each species was estimated, following Valiente-Banuet et al. (2000), as:

REI = Frequency (%) X Density (ind/m^2) X Biomass (m^3)

Frequency values were also used as estimators of distribution. Species appearing less than 33% were considered to have restricted distribution, those occurring in 45–75% sampling units were considered of intermediate distribution, and those occurring in more than 75% sampling units were considered to have wide distribution.

Results

Agricultural systems. Milpa is the main agricultural system; it is the traditional polyculture of maize, beans, and squashes. The irrigated systems (***dat quió***), which are close to the Sendo River, benefited with a system of channels or apantles constructed in pre-Hispanic times. The seasonal systems are in the lowlands areas (***data cubi***) and in the highlands (***dat iquió***).

According to the survey, plots of irrigated milpas may vary from 0.5 to 3 ha, on average 1.06 (SD ±0.62) ha per household. Most households (86%) sow in March and April, and harvest in July and September. Others (14%) sow in February. All households use plough for tilling the ground, except in rocky or pronounced slope terrains, where they use the stick called coa. All households sow the native varieties (white, yellow, pinto, and black) of the creole maize of "de tierra caliente" ("***nin jiquió***"). Approximately one-half of producers combine white and yellow varieties in a plot, and the rest mix all the varieties recorded. Only 3% of people interviewed said to use herbicides, most people weed their plots manually once or twice per production season. Most people (90%) sow the "mosquito" beans (*Phaseolus vulgaris*) and 84% some of the squash species referred to in the irrigated milpa. Presence and maintenance of quelites in milpas were reported by 20% of people surveyed, mostly mentioning the yerbamora (*Solanum nigrescens*) and quintonil (*Amaranthus hybridus*). Maize production per household in this system was 743.4 kg/ha (EE ± 160.83).

The seasonal milpas' plots are on average 1.8 ha (DE ± 1.42) per household. All households use creole varieties of maize. The average production is 639 kg/ha (EE ± 122.40). Sowing is carried out with the first rains in May, June, or July, while the harvest occurs in November, December, or January. Milpa is also a polyculture with the maize varieties, the "milpa" beans or the "mayeso" beans (*P. coccineous*). The squash chilacayota (*Cucurbita ficifolia*) is the most used but it is commonly combined with the other species. The most common quelites are quintonil and yerbamora, and this pattern is due to people's preference and the consequent procurement of these plants (Fig. 2).

The main productive systems complementing the milpa in local subsistence of households are the fruit production system called "huertas," which generate monetary incomes and may include the ganada (*Passiflora ligularis*) garden, the chirimoya (*Annona cherimola*) avocado (*Persea americana*), peach (*Prunus persica*), and chile canario (*Capsicum pubescens*), cultivated in homegardens. The survey allowed estimating that the average income from commercialization of fruit is \$3,789 (± DE 1149) pesos per year per household.

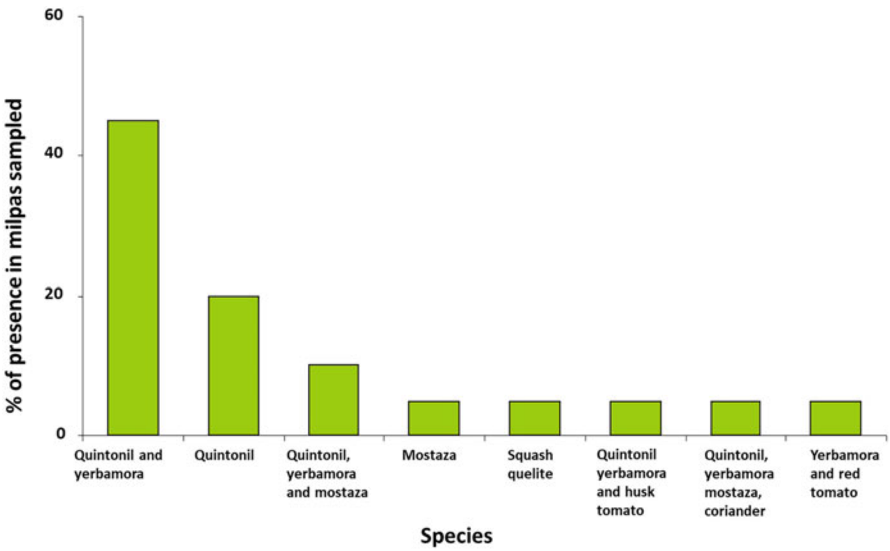

Fig. 2 Frequency of presence of quelites in the milpa system sampled. Quintonil = *Amaranthus hybridus*, yerbamora = *Solanum nigrescens*, mostaza = *Brassica campestris*, husk tomato = *Physalis philadelphica* (weedy green tomato), red tomato = *Solanum lycopersicum* (weedy red tomato)

Homegardens complement the subsistence activities of households, mainly managed by women. These systems have a high diversity of plants and a complex structure with herbaceous, shrubby and arboreal strata, including native and introduced species mainly edible and some medicinal and ornamental. The plot size is on average 1,167 m^2; the dominant species being orange, lemon, banana, chirimoya, prickly pears, coffee, avocado, peaches, chile, granada, guava, epazote, and camomile, all products destined to households' use (Fig. 3).

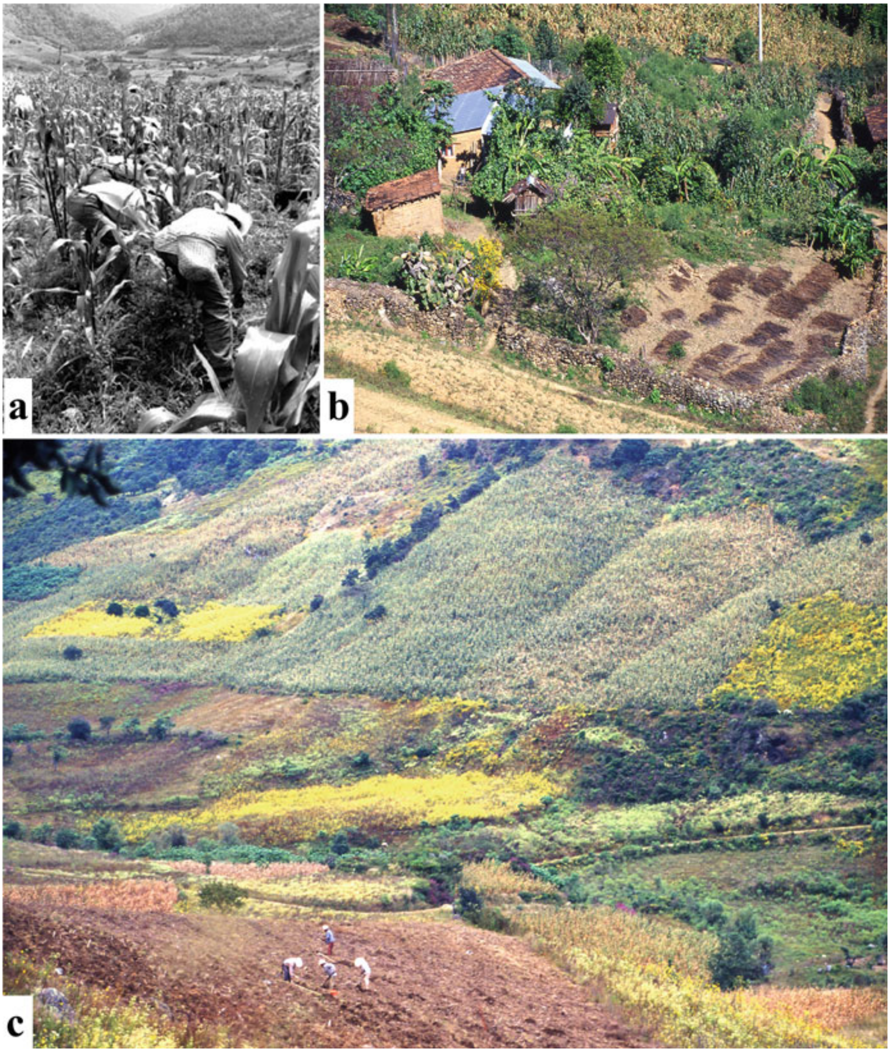

Fig. 3 The main production systems for local people's subsistence in San Lorenzo Pápalo (**a**) the milpa, (**b**) homegardens, and (**c**) the practice of tilling the land in San Lorenzo landscape. (Photos: Leonor Solís)

Production and consumption of agricultural products. According to our surveys, maize production per household is on average 959.31 kg/ha, 95% is directly consumed and the rest is commercialized. On average, each household consumes 22 ± 3.38 kg of maize per week, and 1182.55 ± 176.12 per year. Each household has to buy on average 106.3 kg of maize. For producing maize, people must acquire fertilizers. Therefore, the production is deficient, and households need money to produce it.

Production of beans is on average 63.92 kg (± DE 63.25) per household per year. All this product is directly consumed by households, but these have to buy on average 35.68 kg per year.

Households commonly produce squashes and mainly consume their seeds, while pulp is mainly used to feed pigs. On average they produce 29 squashes per household, all production directly consumed.

Diet. Food of the Cuicatec households is mainly composed by maize tortillas and beans. These elements are commonly complemented with pasta soup or rice. Stoves of the main meal at midday may vary including seasonal forest products (quelites, guajes, plants gathered, animals hunted, or mushrooms collected in forests; Fig. 4). Wild food is particularly abundant during the first months of the rainy season, but some products are available throughout the year. Consumption of chicken meat has increased, with the establishment of the communitarian store; now, households consume this meat once per week on average. Consumption of pork or cattle meat is occasional and mainly associated to parties, twice per year on average; according to the survey 8.06 kg ± 26.06 of meat per household per year. Other products that are common are cheese, pasta, bread and soda, as well as agricultural products that are not produced in the community (mainly rice, tomato, onion, garlic, jalapeño chiles, and potatoes). Table 1 shows a summary of the amounts of these products consumed per household per week.

Cuicatec nomenclature and classification of plants. The Cuicatec nomenclature of plants is generally binomial, with a generic term commonly grouping life forms, characteristics of the environments where they live, among other aspects, and a specific term alluding some characteristics (phenological, morphological, ecological, or other aspects to their use). The classification is based on life forms (mainly herbs, trees, and vines, aspects of use (for instance medicinal plants, quelites, or species producing flowers) and/or morphological characteristics or related to their habitat. In addition, some names are accompanied with varietal terms associated to colors, particular forms, and other attributes.

All trees are called ***ño'o***, which means stick, and ***ya'an***, which refers to trees and shrubs (Table 2), but it is unclear why in some cases it is used a term and in other cases the other. Herbaceous plants are called ***yata***. Shrubs may be classified as trees or herbs. Fruit producing trees are called ***ño'o*** (stick) ***ndut*** (seed). For instance, the hawthorn is named ***ño'o dut iñu***, while its fruit is called ***ndut iñu***, peach trees are called ***ño'o n'deyi*** while their fruit is ***nd'e yi***. The guajes (*Leucaena* spp.) and legume trees and shrubs are grouped with the term ***nin*** (Tables 2 and 11). For figs they use the term ***n'ga***, for oaks ***ya 'a nde 'e***, ***ya'a*** or ***ye*** (Table 2). Pines are grouped with the term ***ya'a ca***; for instance, several pines are called ***ya'a ca cuó jiquió***, *Pinus michoacana* is ***ya'ac toó***, *P. teocote*, *P lawsonii*, *P. pringlei*, and *P. herrerae* are

Fig. 4 Some groups of wild and weedy food obtained from forests and anthropogenic areas. (**a**) Mushrooms collected from temperate forests, (**b**) *Leucaena* or guaje pods, (**c**) larvae of "cuetlas," a nocturnal butterfly, collected from trunks of *Heliocarpus appendiculatus* in the tropical dry forest area, and (**d**) some agricultural products consumed as greens. (Photos: Leonor Solís)

Table 1 Average weekly consumption of food obtained in markets per household

Food	Weekly consumption/household
Rice	1.0 ± (0.55) kg
Tomato	1.8 ± (0.87) kg
Onion	0.9 ± (0.60) kg
Garlic	2.0 ± (2.20) units
Chile	0.3 ± (0.25) kg
Pasta soup	2.7 ± (1.49) bags
Eggs	1.27 ± (1.20) kg
Bread	7.0 ± (7.00) pieces
Soda	4.5 ± (8.50) l
Chicken meat	1.38 ± (1.00) kg
Pig meat	0.12 ± (0.20) kg
Cheese	1.6 ± (1.33) units

called ***ya'ac yudi***. Trees of the genus *Cupressus* are grouped with the term ***ya'a cú,*** while grasses are grouped with the term ***yuni***. These among other examples.

Columnar cacti are named with the generic term ***n'un***, followed by a term distinguishing the species. The spherical cacti are called ***i ndin yava*** and *Opuntia* plants are grouped with the term ***ditu*** (Table 3).

The herbaceous plants are grouped with the term ***yata***, meaning leaf, herb, or plant. The term is used as ***yat*** for naming different herbs (Table 4). A group of herbs is called ***nanda***, the Cuicatec term for flower, and herbs with beautiful flowers are named through the term ***nanda*** or ***nan*** (Table 4). The orchids belong to this group and are grouped with the term ***nanda 'tca***. Vines are grouped with the term ***chivi***, and some of them are considered herbs and called ***yat chivi***. Some examples can be seen in Table 4.

Plants producing tubers and bulbs are grouped with the term ***m'in***. For instance, they recognize the *Dioscorea* spp. bitter camote (appreciated for food) distinguishing one from the cold land (***m'in go' yó***) and other from the warm land (***min goó***). The sweet potato (*Ipomoea batatas*) is called ***m'in ya dí*** and another edible tuber called stinky camote, also edible, is called ***m'in yatim yacú***.

According to information from interviews, the term ***ji*** is commonly used as a prefix to name herbaceous plants used as food or medicine. For instance, the quelites are grouped with the term ***ji v***, and the medicinal plants ***ji quiud*** (Tables 5 and 6, respectively). Ferns are grouped with the term ***ya cua*** (Table 7).

Inventory of Useful Plants

In this study we identified 520 plant species belonging to 110 botanical families, mainly Asteraceae (83 species), Fabaceae (42), Euphorbiaceae (20), Solanaceae (19), Poaceae (13), Cactaceae (13), Lamiaceae (12), Adianthaceae (12), Fagaceae (11), Malvaceae (11), Commelinaceae (10), and Rubiaceae (10). We identified that 367 (70%) species of 87 families that are used with 17 use categories, and 23% of the plant species recorded have more than one use. Most of them (33.84%) are used as

Table 2 Cuicatec nomenclature of trees and shrubs with the prefix ***ño'o*** y ***ya'an***

Species	Life form	Cuicatec life form	Cuicatec generic name	Cuicatec specific name
Rapanea jurgensenii	Tree	***ño'o***	***tu'u***	***de***
Calliandria eryophylla	Tree	***ño'o***	***ya***	***gada***
Juliana adstringens	Tree	***ño'o***	***yo***	***ino***
Gyrocarpus mocinoii	Tree	***ya'an***	***chama***	***cuá***
*Myrica mexicana**	Shrub	***ya'an***	***de***	***cheno***
*Barkleyanthus salicifolius**	Shrub	***ya'an***	***go***	***ido***
Bursera simaruba	Tree	***ya'an***	***guo***	***ó***
Bursera bipinnata	Tree	***ya'an***	***gu***	***ú***
*Arctostaphylos pungens**	Shrub	***ya'an***	***dut***	***inn'i***
FRUIT TREES				
Crataegus mexicana (tejocote)	Tree	***ño'o***	***ndut***	***iñu***
Annona reticulata (anona)	Tree	***ño'o***	***ndut***	***mé***
Musa paradisiaca (plátano)	Tree	***ño'o***	***ya'a***	***tiaca***
Bunchosia palmeri (nanche)	Tree	***ño'o***	***nun***	***güe'e***
GUAJES				
Leucaena esculenta (Guaje colorado)	Tree	***ño'o***	***nin***	***guo'ó***
Leucaena esculenta (Guaje zopilote)	Tree	***ño'o***	***nin***	***jaca***
Desmanthus virgatus (Guaje de ratón)	Shrub	***ño'o***	***nin***	***du'o***
Especie no identificada (unidentified species)	Shrub	***ño'o***	***nin***	***güi***
OAKS				
Quercus rugosa	Tree	***ño'o***	***ya'a nde***	***cuá***
Quercus obtusata	Tree	***ño'o***	***ya'a nde***	***cua***
Quercus glaucoides	Tree	***ño'o***	***ya'a nde***	***tu'u***
Quercus peduncularis	Tree	***ño'o***	***ya'a ja***	***tu'u***
Quercus magnolifolia	Tree	***ño'o***	***ya'a***	***jaba***
Quercus conzatii	Tree	***ño'o***	***ya'a***	***jaá***
Quercus salicifolia	Tree	***ño'o***	***ye***	***cú***
Quercus crassipes	Tree	***ño'o***	***ye***	***co***
Quercus crassifolia	Tree	***ño'o***	***i***	***yoo***
Quercus acutifolia	Tree	***ño'o***	***gño'o***	***cuó***

fodder, 16.15% as food, 14.03% as medicine, and 9.03% as ornamental. Table 8 summarizes the general information of this inventory, while Table 9 shows information on the types of use provided by plant families identified, and Tables 10 and 11 summarize information on the useful plants provided by the different environmental units of the territory.

From the 84 medicinal plant species recorded, people mentioned 36 used for gastrointestinal illnesses, the most important mentioned were *Matricaria recutita*,

Table 3 Cuicatec nomenclature of cacti

Species	Cuicatec generic name	Cuicatec specific name
Pachycereus grandis	***n'un***	***no'o***
Pilosocereus chrysacanthus	***n'un***	***chicú***
Eschontria chiotilla	***n'un***	***ya'a ti***
Stenocereus pruinosus	***n'un***	***na'a***
Stenocereus stellatus	***n'un***	***cuo'o***
OPUNTIA		
Opuntia tomentosa (Nopal Amarillo)	***ditu***	***coó***
Nopalea auberi (Nopal de perrito)	***ditu***	***ya'a na***
Opuntia ficus-indica (Nopal de castilla)	***ditu***	***da'a***

Table 4 Cuicatec nomenclature of herbaceous plants with showy flowers "***nanda***"

Species	Cuicatec generic name	Cuicatec specific name
Eryngeron longipes	***nan***	***cuá jiquió***
Perymenium mendezii	***nan***	***cuó yoino***
Geranium sp.	***nan***	***dio***
Crotalaria rotundifolia	***nan***	***diyu***
Bacopa monieri	***nan***	***guó caya***
Mirabilis jalapa	***nan***	***tin bocheno***

Table 5 Examples of the Cuicatec names of quelites "***ji uv***"

Species	Cuicatec generic name	Cuicatec specific name
Portulaca oleracea (verdolaga)	***jiv***	***di Tú***
Phytolacca icosandra (lengua de vaca)	***jiv***	***duv inó***
Solanum nigrescens (yerbamora)	***jiv***	***du n'e***
Brassica rapa (mostaza)	***jiv duc***	***iya***
Amaranthus hybridus (quintonil)	***jiv***	***do'o***
Chapoquelite	***jiv***	***co'o***

Table 6 Examples of Cuicatec names of medicinal plants "***ji quiud***"

Species	Cuicatec life form	Cuicatec generic name	Cuicatec specific name
Acalypha sp.	***ji quiud***	***van***	***yudi***
Oenothera rosea	***ji quiud***	***lun***	***chi***
Loeselia caerulea	***ji quiud***	***yande***	***bocheno***
Iresine celosia	***ji quiud***	***du***	***atá***
Plantago australis	***ji quiud***	***cu***	***cho***

Artemisia mexicana, *Ruta chalepensis*, *Foeniculum vulgare*, and *Mentha viridis*. For attending respiratory problems, people mentioned 15 species, the most important were *Bouganvillea glabra*, *Eucalyptus globulus*, *Allium sativum*, *Psidium guajava*,

Table 7 Examples of Cuicatec names of ferns "***ya cua***"

Species	Cuicatec life form	Cuicatec generic name	Cuicatec specific name
Adiantum sp.	***Ya cua***	***nuni***	***caya***
Cheilantes sp.	***Yac***	***nuni***	
Pallaea sp.	***Ya cua***	***nuni***	
Phlebodium aureum	***Ya cua***	***nuni***	***jiquió***
Pleopeltis sp.	***Ya cua***	***nuni***	***jiquió***
Polypodium polypoidioides	***Yac eno***	***yaba***	
Pteridium aquilinium	***Ya cua***		
Schizaeocese sp.	***Ya cua***	***caya***	

Table 8 General panorama of useful plant species recorded in San Lorenzo Pápalo

Use	Species
Fodder	176
Edible	84
Medicinal	73
Ornamental	47
Construction	37
Fuel	33
Ceremonial	6
Utensils	5
Toys	4
Shade	3
Beverages	3
Insecticide	2

Table 9 Number of useful plant species per family. Use categories: 1 = medicinal, 2 = fodder, 3 = edible, 4 = ornamental, 5 = ceremonial, 6 = fuel, 7 = utensils, 8 = construction, 9 = live fences, 10 = shade, 11 = handcraft, 12 = poison, 13 = beverage, 14 = glue, 15 = cosmetic, 16 = toy

Family	Species recorded	Useful species	Use type
Asteraceae	83	60	1,2,3,4,5,8
Fabaceae	42	38	1,2,3,4,6,7,8,10,16
Solanaceae	19	16	1,2,3,4
Euphorbiaceae	20	12	1,2,4,8,12
Poaceae	13	12	1,2,3
Cactaceae	13	12	2,3,4,5
Fagaceae	11	11	2,6,8
Adiantaceae	12	7	2,4
Malvaceae	11	7	1,2, 12

Table 10 Number of useful plants per vegetation type

Vegetation type	Species number	Useful species number
Tropical dry forest	144	97
Milpas	90	70
Riparian vegetation	90	68
Pinus michoacana–Q. conzatii forest	71	52
Pinus lawsonii–Q. crassifolia forest	71	42
Homegardens	66	62
Secondary vegetation	57	48
Alnus forest	44	19
Ruderal areas close to the village	41	38
Oak forest (*Quercus rugosa*)	36	22
Oak forest (*Quercus laurina*)	28	16
Granada gardens (*Passiflora ligularis*)	16	16
Oak forest (*Quercus magnolifolia*)	10	10

Table 11 Type of useful species per vegetation type. Uses: 1 = medicinal, 2 = fodder, 3 = Edible, 4 = Ornamental, 5 = Ceremonial, 6 = Utensils, 7 = Construction, 8 = Shade, 9 = Handcrafts, 10 = insecticide, 11 = Poison, 12 = Beverages

						Use						
Vegetation type	1	2	3	4	5	6	7	8	9	10	11	12
Tropical dry forest	18	49	29	14	1	6	0	9	1	0	1	0
Riparian vegetation	16	34	9	8	1	4	3	5	1	0	1	2
Pinus michoacana–Quercus conzatii forest	7	29	3	13	0	11	1	12	0	1	0	0
Pinus lawsonii–Q. crassifolia forest	7	20	3	9	1	9	0	10	0	0	0	0
Quercus magnolifolia forest	1	7	0	0	0	4	0	4	0	1	0	0
Quercus laurina forest	0	8	2	0	0	6	1	8	0	0	0	0
Quercus rugosa forest	2	7	2	3	0	10	1	11	0	0	0	0
Alnus forest	3	9	3	1	0	5	0	6	0	0	0	0
Secondary vegetation	7	32	6	2	1	6	2	8	0	0	0	0
Milpa	19	47	18	2	1	1	1	1	0	0	0	1
Granada gardens	1	7	8	1	0	0	0	3	0	1	0	0
Homegardens	11	7	41	5	2	0	1	3	1	3	0	1

and *Matricaria recutita*, while for fever they mentioned *Sida acuta*, *Gnaphallium* spp., and *Fraxinus purpusii*. For alleviating muscular pain people mentioned 17 species, the most important *Amphipteringium adstringens*, *Pinus* spp., *Equisetum hyemale*, *Ruta chalepensis*, *Selaginella lepodophyla*. For cultural illnesses people mentioned 12 species, the most important *Sambucus mexicana*, *Schinus mole*, *Ruta chalepensis*, *Bursera bipinnata*, and *Ocimum basilicum.*

Table 12 Quelites with the highest cultural importance in San Lorenzo Pápalo

Common name	Species	Frequency of mention
Yerbamora	*Solanum nigrescens*	30
Quintonil	*Amaranthus hybridus*	27
Berro	*Roripa nasturtium–officinale*	17
Mostaza	*Brassica rapa*	14
Chapoquelite	Not determined	14
Verdolaga	*Portulaca oleracea*	13
Pepicha	*Porophyllum tagetoides*	6
Papaloquelite	*Porophyllum ruderale* subsp. *macrocephalum*	5
Lengua de vaca	*Rumex crispus*	4
Col blanca	*Brassica rapa*	4

Table 13 Wild edible fruit with the highest cultural values in San Lorenzo Pápalo (species with * are cultivated domesticated species escaped and adapted into wild environments

Common name	Species	Frequency of mention
Pitaya	*Stenocereus pruinosus*	30
Ciruela amarilla	*Spondias mombin*	18
Chupandía	*Cyrtocarpa procera*	16
Mango	*Mangifera indica**	11
Tuna	*Opuntia* sp.	10
Guayaba	*Psidium guajava**	10
Anona	*Annona reticulata*	6
Zarzamora	*Rubus liebmanii*	6
Tempesquisle	*Sideroxylon palmeri*	6

Table 14 Wild edible seeds with the highest cultural importance in San Lorenzo Pápalo

Common name	Species	Frequency of mention
Guaje colorado	*Leucaena esculenta*	7
Guaje zopilote	*Leucaena esculenta*	3
Guaje de agua	*Leucaena leucocephala* var. *glabrata*	2
Guaje verde	*Leucaena leucocephala*	2
Guaje blanco	*Leucaena leucocephala*	2
Guaje de ratón	*Desmanthus virgatus*	2
Pochote	*Ceiba aesculifolia*	1
Bonete	*Jacarita mexicana*	1
Acazle	No identificada	1

From a total of 84 species recorded as edible plants, local people referred to 18 species as the most important quelites (Table 12), 17 species are the most important wild fruit (Table 13), the edible seeds, mainly from *Leucaena* spp., are indicated in Table 14; whereas the main plants providing subterranean edible parts are of the genera *Dioscorea* (camote amargo, camote de agua, and camote hediondo)

Table 15 Plants used as fuelwood with the highest cultural importance in San Lorenzo Pápalo

Common name	Species	Frequency of mention
Encino cucharo	*Quercus conzatii*	26
Ocote	*Pinus michoacana*	20
Ya'a jaba	*Quercus magnolifolia*	12
Madroño	*Arbutus xalapensis*	11
Encino negro	*Quercus glaucoides*	11
Encino hoja ancha	*Quercus peduncularis*	6
Tepeguaje	*Lysiloma acapulcensis*	4
Ya'a já yoó	*Quercus crassifolia*	3
Ilite	*Alnus firmifolia*	3
Chamizo	*Barkleyanthus salicifolius*	3

and *Ipomoea*. The edible flowers most mentioned are those from *Pilosocereus chrysacanthus*, *Agave* spp., and *Erythrina americana*.

Among the plants used as fuelwood, people mentioned numerous species, but those most frequently used and mentioned by people are indicated in Table 15, while those most frequently mentioned as used for fabricating tools are *Pinus* spp. and *Lysiloma acapulcensis.*

Extraction Rates of Plant Resources

Our evaluations were directed to those exceptional important resources mentioned by local people. Among the wild fruit, for instance, the free lists indicated 17 species but the group with 100% of mention was the columnar cacti fruit (*Stenocereus pruinosus*), the chupandía (*Cyrtocarpa procera*), *Spondias mombin*, and *Diospyros digyna*. We will focus our attention on these species in this chapter.

For people of San Lorenzo Pápalo, the populations of columnar cacti are relatively far from the village, approximately 2 h by walking to arrive to the area of tropical dry forest. But gathering of this fruit is carried out by 90% of people interviewed, from April to early June. *Stenocereus pruinosus* is called ***n'un na'a***; households go to collect these fruits once per week during the production season, seven to eight occasions in a year. On average, they extract 7.36 kg of fruits per household per week, a total of 65.5 kg per household per year (nearly 315 fruits). Since 90% of the families go to collect these fruits, we estimate that the whole village extract annually 10,142.49 kg or 48,762 fruits. Other columnar cacti are also collected (*Stenocereus stellatus*, *Escontria chiotilla*, and *Pilosocereus chrysacanthus*) but these events are occasional. In the case of *Pilosocereus chrysacanthus*, only 3% of people interviewed collect its fruit, but 80% collect its edible flowers.

Prickly pears (*Opuntia* spp.) and pitahaya *Hylocereus undatus* are also collected, but they cultivate *O. ficus-indica* in homegardens and therefore they do not have to go to collect other species in the wild. There is a wild *Hylocereus* species growing in oak forests, but they become established and tolerated in homegardens, where people mostly extract its fruits.

The Sapotaceae tree called tempesquisle (*Sideroxylon palmeri*) was not especially mentioned in the free lists (only 20% of people interviewed mentioned it). However, it is a wild species actively cultivated in homegardens, with a high seasonal consumption (cooked or as fresh fruit) and commercialization in April. The survey revealed that 76% of local people consume tempesquisle fruits in March and April. They said to collect fruits once per week during the production season, and, on average, each household consumes 4.96 kg annually, and the whole community 854.26 kg.

Fruits of chupandía (*Cyrtocarpa procera*) are collected in tropical dry forest areas during September and October. These are collected by 36.6% of the local population, once or twice per year, on average 1.2 kg of fruits per household, or 217.8 kg per year by the whole community.

The ciruelas (*Spondias mombin*) are collected in April and May in areas with tropical dry forest by 20% of households, which consume on average 0.58 kg of these fruit per household per year, and the whole village consume 100.33 kg per year. The fruits of tempesquisle amarillo (*Bumelia laetevirens*) is collected by 10% of people interviewed in May. Households consume approximately 0.18 kg per year, on average, and the whole village 31.53 kg per year.

Fruits of the vine "*chivi yucu*" (*Gonolobus grandiflorus*) are consumed after being roasted. It is collected in the tropical dry forest in October by 10% of the households. Other native fruits collected and consumed are guava (*Psidium guajava*), custard apple (*Annona reticulata*), hawthorn (*Crataegus mexicana*), and the black cherry or capulín de monte (*Prunus serotina* subsp. *capuli*), but because these species are cultivated in homegardens, their gathering in the wild is rather occasional.

Seeds from wild plants are obtained mainly from the "guajes", basically two species of the genus *Leucaena*. These seeds are consumed raw or prepared in several stews and sauces. The green or white guaje (*Leucaena leucocephala*) is consumed by 60% of local people, in March–April and September–October; nearly 20% said to buy these seeds in Tehuacán or Quiotepec the rest collect pods in the tropical dry forest and homegardens. Households collect guaje pods three times per year, nearly 0.25 to 0.5 kg, and 0.66 kg of pods per year, and 113.95 kg by the whole community.

The red guaje (*Leucaena esculenta*) is consumed by 43% of households in October and November. It is collected in tropical dry forest areas three times per year. Each household collects 1.3 kg of pods per year, nearly 216.43 kg per year in the whole community.

The "camote amargo" (*Dioscorea* sp.) is consumed by 76.6% of local people in March and April. It is collected in the tropical dry forest, on average 4.6 kg per household per year 804.1 kg per year in the village.

Among the main edible flowers, the local people mentioned the pipe or colorín flowers (*Erythrina americana*), the agave or maguey flower buds, also called "cacayas" (*Agave* spp.), and the flowers of the "nanabuela" *Pilosocereus chrysacanthus*.

Flowers of *Erythrina americana* are found in all homegardens and granada gardens since their trunks are support of the vines of *Passiflora ligularis* and chayote (*Sechium edule*), and provide shade to coffee. These flowers are consumed by 90% of households between October and December when they collect once or twice per week, on average 0.5 kg. According to the survey, each household collects on average 4.2 kg of flowers per year, and the whole community 715.95 kg of flowers per year.

The “nanabuela” flowers (*Pilosocereus chrysacanthus*) or “***nun chicú***” in Cuicatec are very much appreciated and consumed by 80% of households. These flowers are collected in areas with tropical dry forest from March to May. People collect these flowers twice per year and trap edible lizards (“***yatí***” in Cuicatec), to prepare a soup with lizards and flowers. On average, each household consume 1.6 kg of nanabuela flowers per year, and the whole community 288.81 kg of flowers per year.

Flower buds of maguey or agave maguey (*Agave peacockii* and *A. potatorum*) are called “cacayas” and consumed by 70% of the households. Local people collect cacayas in two periods, from March to May (*A. peacockii*), and from September to November (*A. potatorum*). The flower buds of *Nopalea auberi* (or *Opuntia auberi*) are called “cocoches” and are consumed throughout the year. The latter are cultivated in homegardens, from where people obtain the buds. These are prepared boiled, with tomato, onion and garlic, or in soup.

Through the free lists we identified 18 species of plants called quelites. Most of them are available in the rainy season, growing in milpas or fallow land. The rest grow near or inside streams. The yerbamora (*Solanum nigrescens*) received 100% of mention by people interviewed, while the survey about consumption reported that 93.3% of households consume it. It is collected in milpas, on average 13 days per year; people interviewed said they go to collect this quelite twice per week during the time it is available, at the beginning of the rainy season. Each household consumes, on average 8.2 kg of yerbamora per year. Therefore, the community consumes 772 kg per year.

The quintonil (*Amaranthus hybridus*) is consumed by 93.3% of households, mainly collected in milpas and areas near streams. It is collected when the plant is young and tender, on average 13 times per year, twice or three times during the season when it is available. On average, each household consumes 10.8 kg per year, and 1223.54 kg is consumed by the whole village.

The berro (*Roripa nasturtium-offincinale*) is consumed by 90% of the local households. It is available the whole year, growing in the streams around the village. On average, each household collect 16.96 kg of this quelite per year, which means a total of 2918.26 kg per year is collected by the whole community.

The papaloquelite (*Porophyllum ruderale* subsp. *macrocephalum*) is consumed by 73.3% of households. It is available in milpas, homegardens, and secondary vegetation during the rainy season. On average, a household collect this plant in small amounts 31 times per year, in total 2.74 kg per household per year, 490.96 kg by the whole community.

The pepicha (*Porophyllum tagetoides*) is consumed by 63.3% of households during the rainy season, in the warm land area. Households collect this plant twice per year, on average 0.41 kg, and the whole community consumes approximately 73.39 kg of this plant per year.

The verdolaga (*Portulaca oleracea*) is consumed by 43.3% of households. It is collected in milpas of the warm land area, on average five times per year (1.84 kg) per household, nearly 329.36 kg by the whole community.

The mostaza ("mustard") (*Brassica rapa*) is consumed by 36.6% of households. It is collected in milpas of the cold land area. On average, each household collect three or four times per year and consume 0.93 kg per year, which means that the whole community consumes approximately 166.47 kg of this plant per year.

The chapoquelite is consumed by 30% of households. It is collected in pine-oak forests; it is very much appreciated but because of the distance of the places where it grows, it is collected once per year. On average, each household consumes 0.4 kg per year, approximately 71.6 kg consumed by the whole community.

The quelite lengua de vaca (cow tong quelite) (*Rumex crispus*) is consumed by 26.6% of households. It is collected on average twice per year per household in areas near streams. Each household consumes 0.165 kg per year, which means that the whole community consumes approximately 28.38 kg per year (Table 16).

Extraction of medicinal plants. Local people are progressively switching the traditional remedies for commercial medicines, and, therefore, they extract few amounts of medicinal plants occasionally. Approximately 55% of the medicinal plant species used are cultivated in homegardens, 20% are weedy or ruderal plants, and 25% are wild. All this information indicates that the impact associated to this activity is insignificant.

Fuelwood extraction. Collecting of fuelwood is highly relevant in life of people from San Lorenzo Pápalo (Fig. 5). Although 10% of households have gas stoves, the provision of gas is irregular and, therefore fuelwood is primordial for all households. In addition, it is pertinent to comment that local people said to prefer fuelwood for cooking since flavor and texture of food is better than that prepared with gas stove. Fuelwood extraction is mainly carried out in oak forest areas, mainly those where *Quercus conzatii* and *Q. magnolifolia*, the preferred species, dominate in the vegetation composition. More recently, some trucks have been acquired by people of the village and this condition has favored extracting fuelwood from areas of higher elevations. Nearly 40% of households buy fuelwood to extractors, intensively dedicated to this activity, who have chainsaw and trucks.

Fuelwood extractors cut on average 3 trees per charge contracted, mainly extracting *Quercus conzatii* and *Q. magnolifolia*; this charge provides, on average, fuelwood for 4.5 months to a household. This means that the 40% of local households that buy fuelwood consume on average 558.48 trees of these species per year. Our survey found that samples of fuelwood were composed nearly 60% by *Q. conzatii* and 40% of *Q. magnolifolia*, which indicates that households using this source of fuelwood consume 335.08 trees of *Q. conzatii* per year and 223.39 of *Q. magnolifolia*.

The remaining 60% of local households collect their fuelwood, which is transported by donkeys and the units of measurement of consumption are the "donkey

Table 16 Amounts extracted of the main edible wild and weedy plants in San Lorenzo Pápalo

Plant species	Type of food	Seasonality	Consumption per household (kg)	Annual consumption in the community (kg)
Stenocereus pruinosus	Fruit	April–June	65.5	10,142.50
Roripa nasturtiumofficinale	Quelite	Year round	16.96	2,918.2
Amaranthus hybridus	Quelite	Sept–Nov	10.8	1,223.5
Sideroxilon palmeri	Fruit	March–April	4.96	854.26
Dioscorea sp. (Camote amargo)	Root	March–April	4.6	804.1
Solanum nigrescens	Quelite	Sept–Nov	8.16	772
Erythrina americana	Flower	Oct–Dec	4.2	715.9
Porophyllum ruderale subsp. *macrocephalum*	Quelite	Sept–Nov	2.74	490.96
Portulaca oleracea	Quelite	Sept–Nov	1.84	329.36
Pilosocereus chrysacanthus	Flower	March–May	1.6	288.81
Cyrtocarpa procera	Fruit	Sept–Oct	1.2	217.8
Leucaena esculenta	Seed	Oct–Nov	1.3	216.4
Brassica rapa	Quelite	Sept–Nov	0.93	166.47
Leucaena leucocephala	Seed	Oct–Nov	0.66	113.95
Spondias mombin	Fruit	April–May	0.58	100.33
Porophyllum tagetoides	Quelite	Sept–Nov	0.41	73.93
Chapoquelite	Quelite	Year round	0.4	71.6
Bumelia laetevirens	Fruit	April–May	0.18	31.53
Rumex crispus	Quelite	Year round	0.16	28.38

charges" (the amount of fuelwood that on average a donkey is able to bear). According to our survey, each household extracts approximately 2.64 donkey charges per week. These charges are on average 65.5 kg, which means that the 60% of local households consume 169 kg of fuelwood per week, which means nearly 940.316 t per year.

Through measuring the daily consumption of fuelwood, we estimated that each household consumes 6.75 ton of fuelwood per year (Table 17). This figure allows estimating that the annual consumption by the whole community is nearly 1,206.08 ton per year. Based on the analysis of average composition of samples of fuelwood used in the daily life, we found that households mainly consume *Q. conzatii*, *Q. magnolifolia*, *Q. glaucoides*, *Pinus* spp., *Lysiloma acapulcensis*, and *Q. peduncularis* (Fig. 6). These are not the only species used; in fact, the survey recorded the mention of other species like *Arbutus xalapensis*, *Acacia pennatula*, and *A. farnesiana*. Figure 6 shows the panorama of the average composition of fuelwood samples recorded in a day per household.

Fig. 5 General aspect of extraction and use of fuelwood for subsistence in San Lorenzo Pápalo. (Photos: Leonor Solís)

Distribution and Abundance of the Main Plant Resources

Table 18 summarizes the average estimation of density, biomass, and frequency of the main plant species recorded in the vegetation sampling carried out in each vegetation type analyzed. These samplings allowed identifying the distribution and

Table 17 Average weight and volume of fuelwood consumed per household and per the whole community per year

Species	Tons/village/ year	Volume (m^3)/ household/year	Volume (m^3) / village/year
Encino cucharo (*Quercus conzatii*)	718.685	120.77	21,619
Encino blanco (*Q. magnolifolia*)	420.321	73.29	13,119
Encino negro (*Q. glaucoides*)	91.46	8.39	1,502.7
Encino (*Q.peduncularis*)	23.52	6.3	1,143.3
Pino (*Pinus* spp.)	20.907	5.84	1,045
Tepeguaje (*Lysiloma acapulcensis*)	7.84	0.69	124.13
Total	1,206.068	215.28	38,553.13

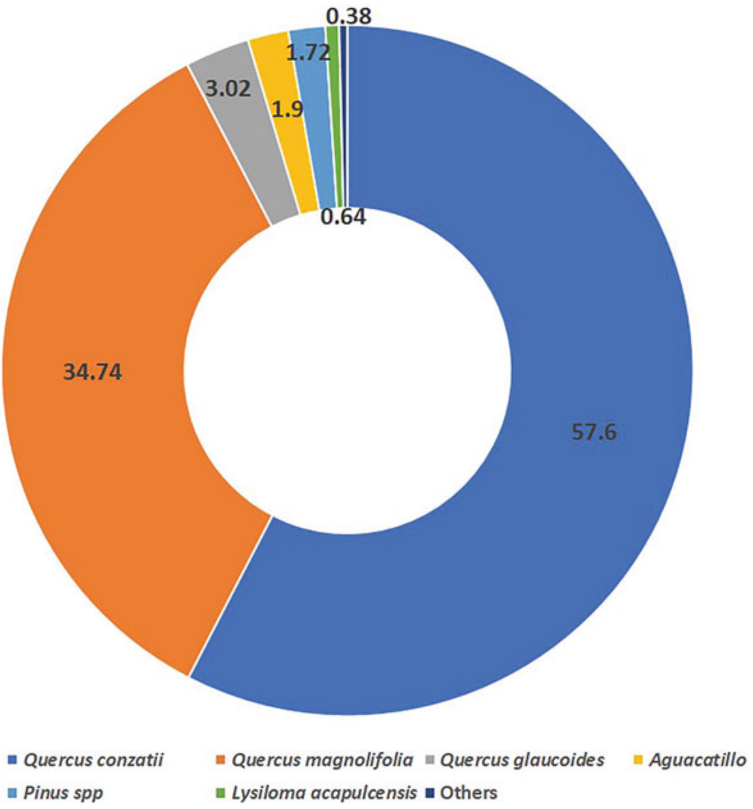

Fig. 6 The average composition of fuelwood documented in households sampled. Aguacatillo is an unidentified species of the family Lauraceae (it was not identified from wood samples), while the category “others” include several unidentified species occurring in small amounts in fuelwood samples

Table 18 General plant species richness and useful plant species richness per environmental unit type

Environmental unit type	Species number	Number of useful species	% of useful species
Tropical dry forest	144	97	67.36
Milpas	90	70	77.78
Riparian vegetation	90	68	75.56
Pinus michoacana–Q. conzatii forest	71	52	73.24
Pinus lawsonii–Q. crassifolia forest	71	42	59.15
Homegardens	66	62	93.94
Secondary Vegetation	57	48	84.21
Alnus forest	44	19	43.18
Ruderal areas near the village	41	38	92.68
Quercus rugosa forest	36	22	61.11
Quercus laurina forest	28	16	57.14
Granada gardens	16	16	100
Quercus magnolifolia forest	10	10	100

abundance of the most used plants and compare this information with that obtained from surveys of extraction of products. In this chapter we only show the information considered more relevant for such an analysis. Other details will be published elsewhere and can be consulted in Solis (2006). A first aspect to highlight is in relation to the differential richness of species recorded on each vegetation type and the proportion of species that supply a benefit to people. As indicated in Table 18, the tropical dry forest has the highest plant species richness, most of them contributing to satisfy different human needs. The riparian vegetation is also outstanding in terms of diversity, while temperate forests (oak forest and pine forests) are important because of their extent and the arboreal biomass they harbor. On average, more than 60% of the species recorded in the vegetation sampling are plants used by local people. But it is also relevant to highlight that the anthropized vegetation types sampled (milpas, homegardens, and secondary vegetation) are all areas with exceptionally high proportion of plant species used by people.

To summarize the information, Figs. 7, 8, 9, 10, 11, and 12 provide graphic illustrations of the different types of resources that are more abundant in the environmental units sampled. Each environmental unit provides different types of products. For instance, tropical dry forest, riparian vegetation, milpas, and secondary vegetation are main sources of fodder for livestock (Fig. 7); milpas, homegardens, and tropical dry forests are by far the main sources of food, milpas, and homegardens providing cultivated and weedy food, and the tropical dry forest supplying wild food (Fig. 8). Milpas, homegardens, riparian vegetation, and tropical dry forest are the main sources of medicinal plants, which, as mentioned, are mainly cultivated (Fig. 9). Oak and pine forest types and the tropical dry forests are the main sources of fuelwood and materials for construction, while ornamental plants are obtained

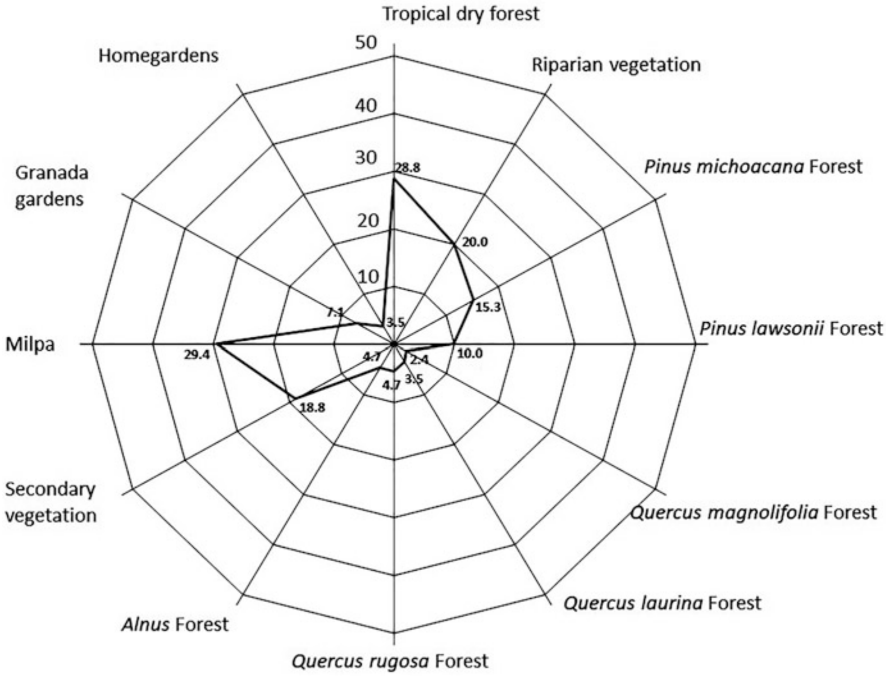

Fig. 7 Main environmental sources providing fodder species

from some pine forest, tropical dry forest, and riparian vegetation (Figs. 10, 11, 12). The analysis of distribution of plant species indicates that 61.5% of the useful plant species occur in only one vegetation type. The figures referred to and this information illustrate that the different ecosystem types are providing also different types of plant resources, and this is an important aspect to analyze the complementarity of them to people's life.

Discussion and Conclusions

The Cuicatec are an ancient group of people inhabiting the mountains of Mexico, closely related with the Mixtec, but relatively poorly known. Ours is one of the few, if not the only ethnobotanical study with the Cuicatec. Such scarcity of information is a condition that still predominates for most native cultures of Mexico and indicates the importance of enhancing priority research among these groups (Camou et al. 2016). Nomenclature and classification of plants have great similarities to those reported for the Mixtec, for whom life forms like trees (***yutu***), herbs (***yuku***), vines (***yo'ó***), the shrubs either herbs or trees; the cultural categories analogous to life forms, for instance quelites (***yiwa***), flowers (***ita***), and grasses (***icha***), are the principles for the general classification of plants, then followed by terms indicating

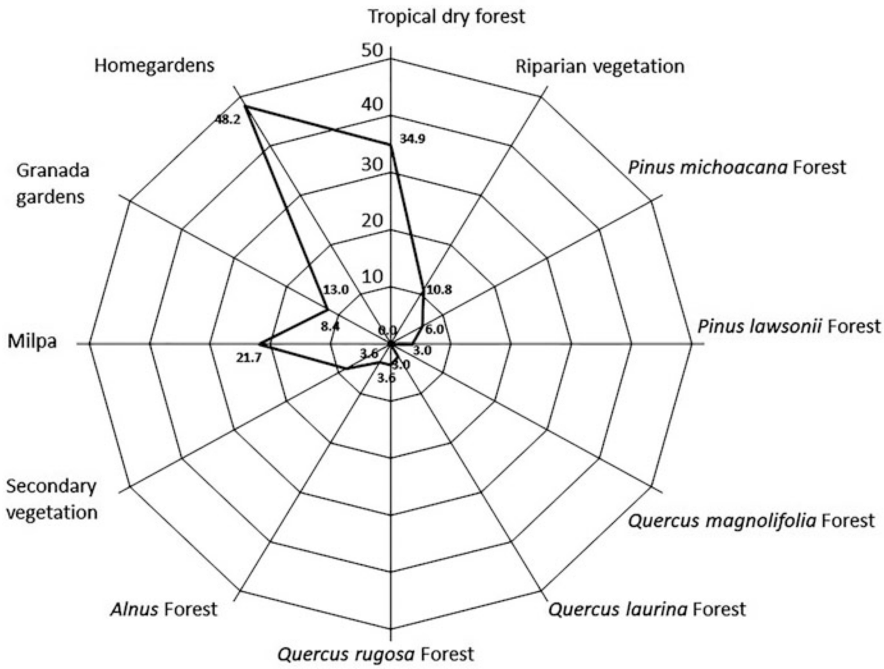

Fig. 8 Main environmental sources providing edible species

generic, specific, and varietal categories (Casas et al. 1994; De Ávila 2004). Deeper linguistic studies among the Mixtec were conducted by De Ávila (2010), and it is widely recommended to the readers to follow that interesting piece of work, which is extraordinarily helpful to understand the Cuicatec classification of plants. That study helped very much to organize the main units of classification that we documented among the Cuicatec.

As reviewed in this chapter, the subsistence of the Cuicatec strongly depends on agriculture, for direct consumption of products that are staple food (maize and beans principally), but also to obtain monetary income from fruit production in granada (*Passiflora ligularis*) plantations and homegardens, which are commercialized and allow obtaining the staple products that their agricultural systems are not able to satisfy. Livestock is important for obtaining monetary income (mainly from sheep and goats), as labor animals (cattle, donkeys, and horses), while backyard animals (mainly hens, turkeys, and pigs) are destined to occasional consumption of their products. Monetary incomes are complemented by the remittances derived from jobs out of the village although these are irregular and difficult to evaluate. And all these sources of money have gained importance in the last decades, through a process in which commercial products associated to the food system (chemical fertilizers for agriculture, chicken meat in the communitarian store, buying staple food in markets, and buying fuelwood by nearly half of local households).

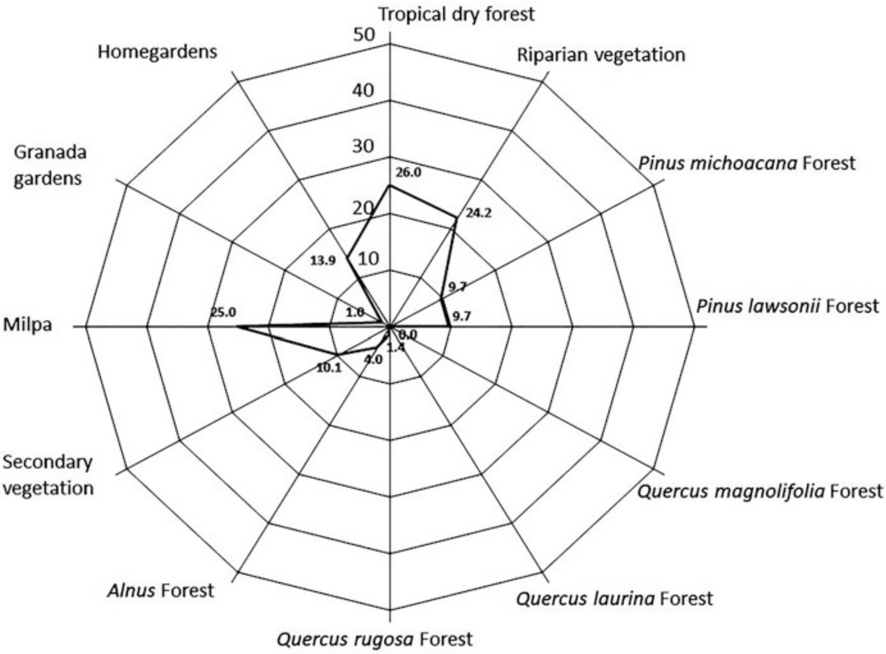

Fig. 9 Main sources of medicinal plants

Maybe, the most relevant finding of this study is the ongoing use and strong human culture associated to using wild and weedy plants to satisfy different needs, mainly food, fuelwood, and construction. Our study identified that the satisfaction of these needs could be also the most meaningful in terms of possible impact on natural ecosystems and biodiversity occurring in the territory of San Lorenzo Pápalo. We have seen that procuring of food impacts on local ecosystems mainly through changes in land use, the transformation of forest into agricultural plots. Gathering of food has low impact on natural ecosystems since the highest diversity and abundance of edible biomass occur in the production systems, as weedy plants (quelites), while other significant wild food consists of fruits and seeds, whose gathering is in important amounts (as it is the case of *Stenocereus pruinosus*), but the impact of collecting these parts is generally low (Blancas et al. 2010; Torres-García et al. 2015, 2020; Arellanes et al. 2018). The impact could be more relevant through the gathering of edible tubers, roots and bulbs, since the extraction of these parts may cause severe damage to plants and may affect their survival (Blancas et al. 2010); however, the gathering of these edible parts is relatively low. Therefore, the main challenge for the community to maintain sustainable ways of procuring food is mainly related to strategies to maintain the food production systems functioning in the long term, in order to decrease the rate of clearing land for new agricultural plots.

The impact of livestock has not been evaluated; for the moment we identified the main areas used for grassing the animals through the free raising regime. But it is still

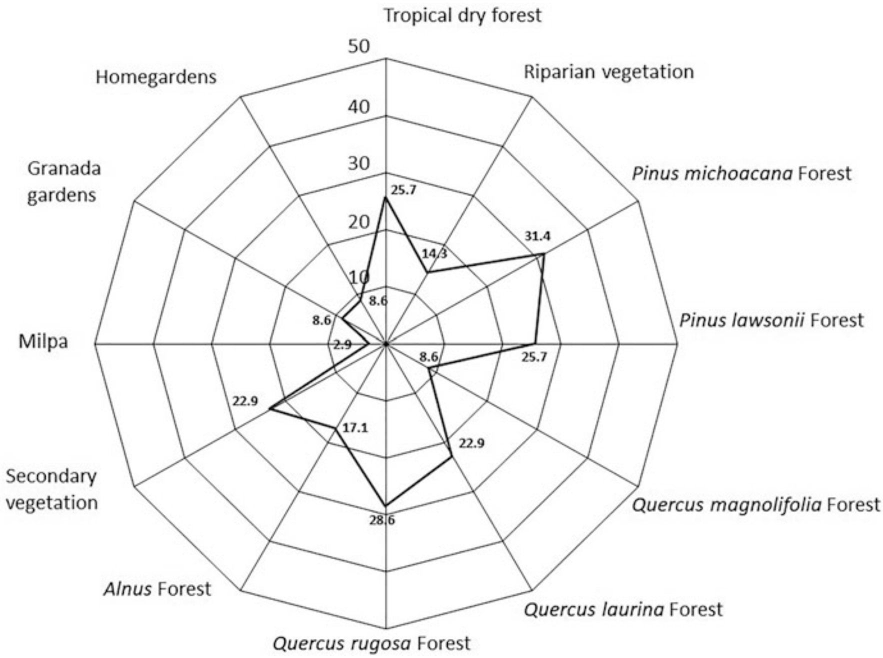

Fig. 10 Main sources of fuelwood

necessary to analyze the number of animals raised, and the real impact on these areas to develop proposals of optimal management of grassing areas and size of herds with ecological criteria.

Hunting and gathering of animals and their products are mainly directed to obtain food (Solís and Casas 2019). Our study analyzed the potential impact of these activities on particular species, those more frequently hunted (squirrels and armadillo), and those affected by ecosystem transformation (deer), but these studies require more specific monitoring of the effects of these practices on particular populations. These studies would be important for contributing ecological criteria for processes of local regulations construction.

Apart from transformation of forests to production systems, wood extraction is apparently the most important practice impacting on forests. The extraction of wood for construction may cause a significant impact during certain periods. For instance, because of the occurrence of severe landslides and floods part of the town had to move from one area to another and the construction of new houses represented a sudden impact associated to this activity, but these events are apparently rather rare, and the construction of new houses or the renovation of part of their structure may be occasional. What is more significant, due to the frequency and systematic occurrence, is fuelwood extraction. There are several options developed in areas of Mexico that could be locally adopted. One of the most viable, because of cultural and technical reasons, is the promotion of programs for constructing efficient fuelwood stoves,

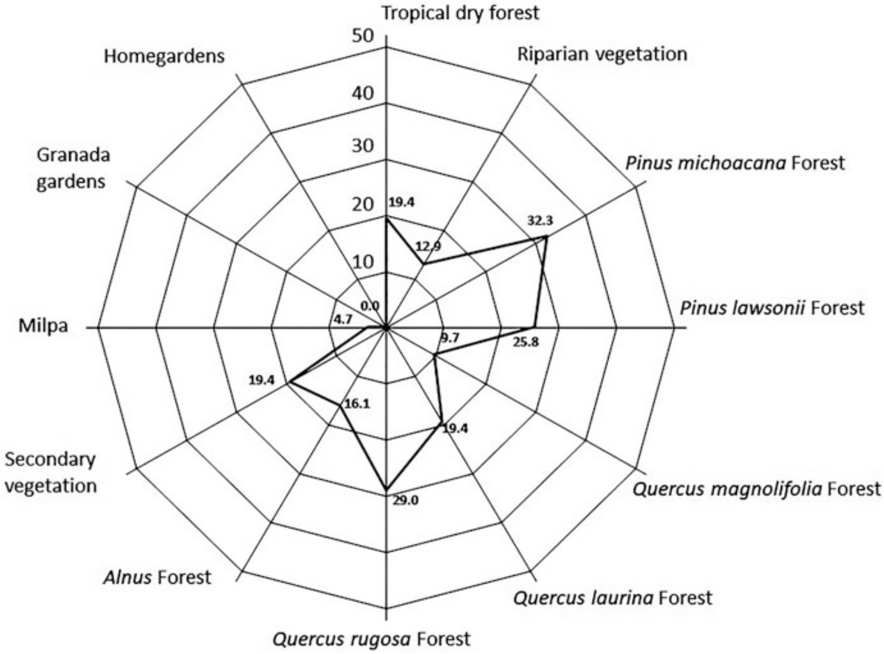

Fig. 11 Main environmental sources of materials for construction

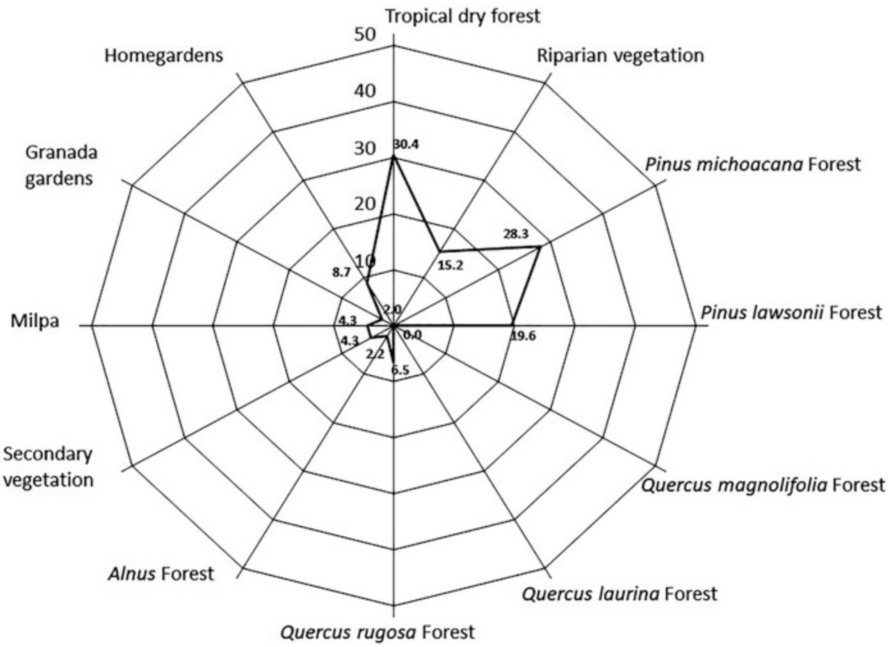

Fig. 12 Main environmental sources of ornamental plants

which are being designed by several organizations and have demonstrated to significantly reduce the amounts of fuelwood used (Berrueta et al. 2017; Pine et al. 2011). According to our current diagnostic, this activity is the most impacting on natural ecosystem, threatening two oak species. Using efficient stoves not only would help to reduce the amount of biofuel but would favor a diversification of species suitable to be used, thus buffering the impact on those identified oak species.

Undoubtedly, the use of a broad spectrum of plants for satisfying each important human need is a way to guarantee buffering the effect of impact on particular species. As in the case of fuelwood, looking for the ways different species may be similarly valued for the different activities could be a way to contribute to strengthen the buffering effect. This is a process that continually happens in the real situations. An appreciated edible plant like the chapoquelite is not frequently consumed since its availability is restricted by distance from the village and its low abundance. In part this is a situation that has motivated people to put in practice management techniques such as cultivation of some species. But not only cultivation is an option, in fact, commonly it is not feasible (Casas et al. 1997; Blancas et al. 2010); therefore, documenting the local strategies that people practice to substituting valuable products and developing innovations in this direction is probably as important as to experiment cultivation. Using diversity has been part of the successful experience of humans to maintain ecosystems they interact with. In part because they have several options to satisfy a need and this fact allows increasing their resilience capacity. Similarly, strategies of using different environmental units represent extraordinary important ways to complement the acquisitions of products and buffering impact on particular ecosystems. Our study illustrates how the Cuicatec of San Lorenzo Pápalo makes use of different species and different environmental units, complementing the products that can be obtained from each unit. The location of the village is strategic, it is settled on the intermediate elevation of the territory of the community, which favors the access to products from the warm and cold lands, and therefore favors the complementarity of products and ecosystems in their life.

The local diversity of plant resources documented in this study represents nearly 15% of the whole diversity of plants utilized by peoples in the whole region. And, as mentioned in the Introduction section, the ethnofloristic inventory of the Tehuacan Valley is one of the richest documented in Mexico. This figure helps to dimension the relevance of diversity in the Cuicatec life, which is similar to what has been documented among other human cultures of the region, like the Ixcatec, the Nahua, the Mixtec, the Popolocan, and even the mestizo rural people. Using the diversity favors the conservation of diversity, and this is an important premise for designing management programs in different contexts, and especially in the Biosphere Reserve Tehuacán-Cuicatlán, where these people live, and where they have developed experiences and techniques to do it.

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