Mazahua Ethnobotany: Traditional Ecological Knowledge, Management, and Local People Subsistence

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Abstract

This study documents the Mazahua ecological knowledge of plants, their nomenclature and classification, and their role in subsistence of people in a village of the Monarch Butterfly Biosphere Reserve, Mexico. We registered 213 useful plant species within the territory studied. *Prunus serotina, Rubus liebmannii,* and *Crataegus mexicana* were the main species providing wild fruits gathered by the Mazahua people, whereas *Brassica campestris, Rorippa nasturtium-aquaticum, Chenopodium berlandieri,* and *Amaranthus hybridus* were the principal non-crop greens locally consumed. Extraction of medicinal plants is low but gathering of flowers of *Ternstroemia* spp. for commercialization involves practices that endanger local populations of these plants. All households of the village make use of fuelwood, mainly of pine and oak species; in addition, they practice livestock, mostly extensive free raising of cows and sheep, but commonly people gather some wild and weedy plants for feeding their animals.

Spatial and temporal availability of useful plants were investigated to determine their abundance and relation to their role in people subsistence throughout the year. The information was compared with data on extraction rates of the main useful plants to analyze conditions for sustainable use of plant resources. Nearly half of the territory of the village was covered by forest areas, including different types of pine-oak-fir forests and riparian vegetation. The other half of the territory has been transformed, including agricultural areas and secondary scrub

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grasslands. Although the village studied (Francisco Serrato, Michoacan) is part of the core zone and the buffer zone of the Monarch Butterfly Biosphere Reserve, during the period of 2001–2006 its territory suffered a drastic deforestation caused by the influence of outsider organized crime. Such action decreased the forest area of the community nearly 350 ha of the *Abies* forest.

The highest diversity of useful trees and shrubs was found in the riparian vegetation, where impact of extraction is relatively low. Agricultural areas lack arboreal vegetation but have the highest diversity of herbaceous useful plants mainly including weedy plants gathered for human food as greens and fodder. Pine-oak associations have intermediate diversity of useful trees and shrubs and herbs but are the main reservoirs of biomass of useful plants and are also the most used areas by people. Non-timber plant resources are relatively abundant and extraction rates did not appear to endanger their populations. However, the extraction of *Ternstroemia lineata* flowers for commercialization as medicine, and fuelwood of *Pinus pseudostrobus*, *Quercu*s spp., *Abies religiosa*, *Alnus* spp., and *Comarostaphylis* spp. used and commercialized, may represent serious risks to sustainable maintenance of their populations. In addition, the timber extraction to which the forest region has been subject for decades severely threatens the integrity of the forest ecosystems of the Monarch Butterfly Biosphere Reserve. The bases for sustainable use of forests are the traditional forest management practices and some aspects about these practices are discussed.

Introduction

This research was conducted to document the botanical knowledge of the Mazahua, an indigenous group belonging to the Otomanguean language family with two linguistic variants, the eastern or *jnatrjo* and the western one or *jnatjo*. In the Mazahua communities, the language, the traditional dress for women, the customs, and traditions are preserved (Forero 1997; Hopkins and Josserand 1979). In 2015, a total of 147,088 speakers of the Mazahua language were registered by the governmental census (INEGI 2015). The Mazahua communities live mostly in Central Mexico, in ten municipalities of the state of Mexico and seven of the state of Michoacán, and this area includes the Monarch Butterfly Biosphere Reserve (CONANP 2001).

People in some Mazahua villages mainly practice productive activities such as agriculture, cattle and sheep raising, extraction of forest products, and elaboration of diverse handicrafts made of wool, mud ceramics, and wood. The region covers about 56,260 ha (CONANP 2001) and has a high biological diversity that includes more than 400 plant species within the core zones of the Biosphere Reserve (Cornejo-Tenorio et al. 2003).

The Mazahua, Matlatzinca, Otomí, Nahua, and Purépecha groups have occupied and managed the Michoacán territory of the Biosphere Reserve for centuries. Forests have been cleared up progressively to support agriculture and domestic animals to sustain the settlements as well as to provide wood for the establishing of villages and

people subsistence. Clearing of lands for agriculture has determined a continuous pressure on local ecosystems since pre-Hispanic times. However, pressure has been particularly strong during the last decades, mainly because of illegal logging carried out by organized crime, and partly also because the communitarian exploitation of natural resources increased with the population growth. A dynamic of forest loss from *Abies* and *Pinus* 1,200–2,500 ha was recorded for the Monarch Butterfly Biosphere Reserve during the period 2000–2006, and an annual rate of 329–500 ha per year during the period from 2006–2010 (López-García 2007; Champo-Jiménez et al. 2012), and the process continues until the present. Deforestation has been caused by agricultural clearing and domestic legal timber extraction and, therefore, alternative land use is necessary to conserve the regional forests and recognize their contribution to local subsistence of non-timber forest resources occurring in forest areas. However, the main destructive activity is the illegal extraction of wood by the organized crime, a great and complex problem that requires special attention by the Mexican authorities. Here we will analyze the possible plans and activities that can be promoted in association with local people, but the control of the timber extracting mafias by the government is the most imperative action.

Worldwide, there is an increasing interest in using and commercializing non-timber forest resources. Some of them have high cultural and economic value and are considered as actual or potential bases for practices of low impact on ecosystems that could substitute timber extraction and would contribute to conservation of forests (Balick and Mendelsohn 1992; Salick et al. 1995). Such resources offer the possibility of finding valuable options of non-timber forest products for both conservation and wealth of local peoples. Searching for such options requires documenting cultural and economic aspects in relation to use of plant resources and traditional management techniques practiced on them, as well as ecological information of plant populations and communities, which may make valuable contributions for defining criteria to sustainable management of forests. These are currently among the main challenges of ethnobotanical and ecological research that can contribute with proposals for sustainable use and conservation of plant resources and the ecosystems these belong to (Salick et al. 1999; Shanley et al. 2002).

Use and commercialization of non-timber plant resources are potential alternative practices with low impact on ecosystems in some areas (Shanley et al. 2002). Non-timber forest resources offer products such as food, fodder, medicine, materials for construction, handicrafts, and fuel, and the indigenous peoples of the region we studied have used these resources for centuries. Therefore, identifying useful resources, evaluating their economic potential, and designing forms of utilization to ensure their future maintenance should be the first aim of ethnobotanical research to contribute to their conservation and sustainable management. This information may be a valuable support, based on the local knowledge, forms of use and management, and helping to estimate the abundance and the rates of extraction of wild and weedy plant resources, especially those that are more important for people's subsistence. This information shared with local authorities of the communities, peasant households, and schools may be useful to contribute to design programs for preservation of resources and maintaining the biocultural memory.

For designing strategies of resource management congruent with the principles of sustainability, it is firstly necessary to document what biotic resources are available in an area, those that are wild, weedy, and domesticated, and identifying which are considered more important resources for subsistence by local people. Then, it is helpful to investigate how is the distribution and abundance of the principal resources, and what is the biodiversity they are associated to. In addition, what are the current rhythms of extraction of useful products and those that would be the appropriate to ensure the long-term maintenance of plant populations and biotic communities they belong to.

Ecological studies of populations and communities of plant resources, especially of those species with commercial value and more intensively extracted, could establish the bases to design strategies of sustainable management and techniques to increase their availability (Flachsenberg and Galletti 1998; Von Gadow et al. 2012). For such purpose, it is particularly helpful to characterize the diversity of useful plants existing in the different local ecosystems, as well as their abundance and temporal availability. This information may help identifying those species endangered under the present patterns of extraction, and may be the basis for planning extraction of products under sustainable criteria.

We conducted our research having these premises in mind. In this chapter, we summarize the information we documented on the Mazahua traditional ecological knowledge of plants, including nomenclature, classification, forms of use and management, and their role in local people subsistence. We aimed, in principle, to generate an inventory of the useful plants locally available but thinking in the socioecological information needed to support sustainable management plans. We emphasized our efforts in identifying those species with higher risk to disappear under the current extraction rates, and those species offering potential opportunities for production. We finally discuss the management requirements for local sustainable use of plant resources.

Materials and Methods

Study Site

The research was conducted in the village of Francisco Serrato, municipality of Zitácuaro, Michoacán (Fig. 1). The region has an elevations range between 2,400 and 3,000 m with temperate climate. Natural vegetation with areas of pine forests (mainly *Pinus pseudostrobus*) and pine in association with oaks (*Quercus laurina*, *Q. rugosa*, and *Q. crassifolia*), with oaks and firs (*Abies religiosa*), and with the Mexican alder *Alnus jorullensis* and *A. acuminata*.

People maintain the Mazahua language and cultural customs, including the use of traditional clothes among women (Fig. 2). Agriculture is the main economic activity, involving the seasonal cultivation of maize, beans, wheat, barley, and potatoes. Moreover, raising of chickens, turkeys, pigs, and sheep, as well as the extraction of wood for the construction of houses, fences, tools, and for commercialization are also relevant activities. Gathering of plants and other resources complements the

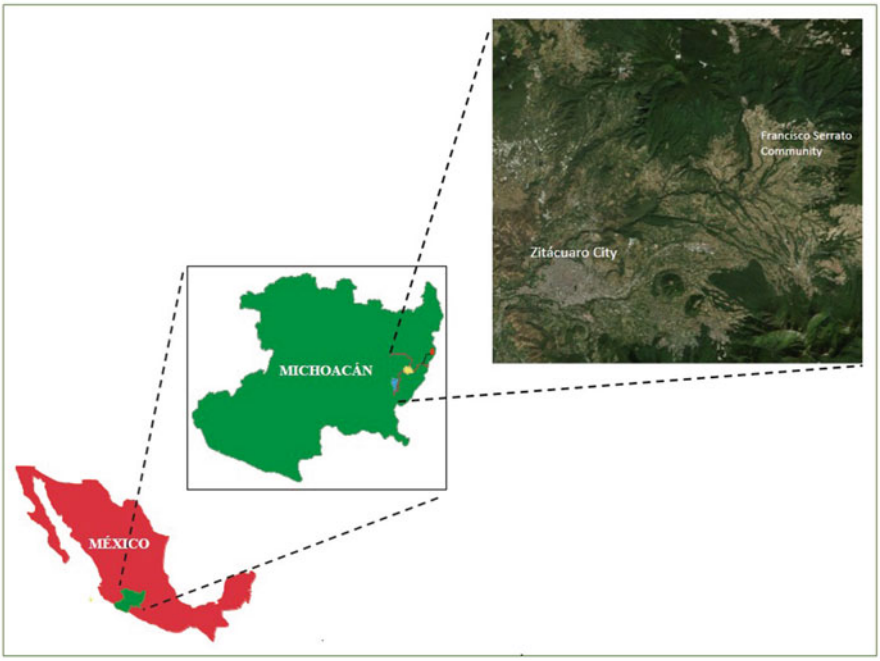

Fig. 1 Geographical location of the village of Francisco Serrato, in the municipality of Zitácuaro, Michoacán, Central Mexico. (Geographic information source Esri Satellite imagery)

peasant economy, contributes to the fulfillment of the needs for food, medicine, and fodder, and is a source of monetary income from the commercialization of useful products (Farfán et al. 2007). The land tenure is collective, mostly communal (89.8% of the total area) and ejidal (10.2% of the total area).

Data Collection

Ethnobotanical research included the documentation of plant names, uses, and forms of management, with the collaboration of 30 Mazahua people. For documenting common names of plants, lists of names were audio-recorded in the Mazahua language, then transcribed with the help of a person speaking the Mazahua language with knowledge in Mazahua linguistics and expertise in editing educational books in this language. Mazahua classification of plants was analyzed based on nomenclature and through close-ended questions showing voucher specimens to five people.

Botanical specimens were collected in different types of forest vegetation as well as in agricultural systems, disturbed areas, and roadsides. Voucher specimens of plants were deposited into the National Herbarium of Mexico (MEXU), as well as in the herbaria of the Universidad Michoacana de San Nicolás de Hidalgo (EBUM), and the Instituto de Ecología, A. C. at Pátzcuaro, Michoacán, Mexico (IEB).

Fig. 2 Mazahua people: (**a**) Mazahua women in traditional dress, (**b**) traditional food. (Photo Aviña, 2014 http://jeseltorres.blogspot.com/2014/11/mazahuas.html)

The interviews were used to record information on the production and consumption of forest products to establish the basic subsistence pattern of local people and to analyze the role of forest products in subsistence. This information was compared with ecological information on distribution and abundance of plant resources.

Mapping of Environmental Units

General environmental units analyzed included the natural vegetation types, and the agricultural areas. These environmental units were mapped by using geographical information system, and field observations georeferencing points through a GPS, which allowed the estimation of the extent of areas of the environmental units.

Distribution and Abundance of Useful Plants

Vegetation was sampled in each environmental unit through 500 m^2 squares, subdivided into five 100 m^2 squares. A total of 1,500 m^2 were sampled in each of the different vegetation types. All individuals of shrubs and trees species included in the squares sampled were counted to estimate their density (total number of individuals of each species per sampled unit). Herbaceous plants were sampled through 1 m^2 square, which were placed once, at random, within each of the 100 m^2 squares. Agricultural fields comprised only herbaceous plants and these plants were sampled similarly as in forest units.

Plant diversity of the different vegetation types was calculated based on data of density of tree and shrub species in the sites sampled, pooled per vegetation type. Diversity of herbaceous plants in the different environmental units studied was calculated based on data of presence/absence of plant species.

Temporal Availability of Useful Plants

Information on temporal availability of useful parts of all useful plant species was obtained through structured interviews with people of 30 Mazahua households.

Results

Traditional ecological knowledge. Mazahua nomenclature and classification of plants. The Mazahua system of classification of the natural world considers as first level of inclusion the moving elements of nature (***tenxe yo nyomb'u***), a group that comprises all biotic and abiotic elements that have movement such as animals, water, and wind. The other group at this first level of inclusion clusters unmoving elements (***tenxe yo dya nyomb'u***), which include plants, rocks, and mushrooms.

The Mazahua system of classification of plants uses five life-form categories: ***xizaa*** meaning tree and stick, which includes trees and woody tall shrubs, ***pzijño*** that includes small shrubs and tall herbaceous woody plants, ***ts'i pzijño*** grouping small herbs, and ***ngüeí*** that comprises some ferns, since some of them are grouped with the small herbs (i.e., *Adiantum andicola* is called ***ts'i banjua*** and *Cheilanthes chaerophylla* is called ***ts'ngüeí***; the prefix ***ts'*** **is** used to name herbs). The prefix ***nrr*** includes plants producing large, beautifully colored flowers, no matters if they are herbaceous or woody plants.

Mazahua nomenclature uses generic names and commonly includes a prefix or suffix indicating the "life-form" category of a plant. For instance, the prefix ***ts'*** indicates that the plant is a small herb (Table 1), while the suffix ***pzijño*** includes shrubs and tall herbaceous plants. Thus, in the Mazahua nomenclature the plants of the Poaceae and Cyperaceae families are considered small herbaceous plants and are grouped under the word ***ts'nrreb'i***. Trees are named by using the prefix ***xi*** (apparently a contraction of the term ***xizaa***); for instance, *Pinus pseudostrobus* is named ***xivatí***, *Quercus laurina* is ***xizhaa***, and *Q. rugosa* and *Q. crassifolia* are named using the term ***xibatr'i***.

Table 1 Mazahua nomenclature at the form level (In the Mazahua names, letters in bold indicate the classifying terms)

Life form	Scientific name	Mazahua name
Trees	*Pinus* spp.	**xi**vatí
	Buddleia cordata	**xij**'ta
	Quercus spp.	**xi**lojo
Small herbs	*Iresine celosia*	**Ts'in**guitz'ajna
	Euphorbia dentata	**ts'in**rroí
	Salvia fulgens	**ts'in**barenzé
Shrubs and large herbs	*Eupatorium* spp. and *Stevia* spp.	Pe**pziño**
	Salvia mexicana	mb'o**pziño**tr'eje
	Polygonum aviculare	**pziño**dyotr'eje
Ferns	*Chelianthes chaerophylla*	**ngueí**
	Adiantum andicola	**ts'ingüeí**tr'eje

The Mazahua nomenclature is commonly binomial, with generic categories of plants, named considering the morphological similarities among them. For instance, most plants of the genus *Salvia* are classified under the term ***k'anrrejna***, whereas plants of the genera *Tagetes* and *Senecio* are grouped together under the term ***k'axtr'u nrran-j'a***. Additionally, names include specific epithets indicating the place where the plants are found or distinctive morphological characteristics. For instance, people use the word ***tr'eje*** to indicate that plants are from the forest, as in the case of *Cheilanthes chaerophylla* which is called ***ts'ingüeí tr'eje***, a term indicating that these plants are herbaceous (***ts'***) ferns (***ngüeí***) and occurring in the forest (***tr'eje***).

Use forms of plants. A total of 213 useful plant species were identified in the community studied (Table 2). Most useful plant species are wild (164 species), mainly occurring in pine-oak forests (94 species) and pine-oak-fir forests (81 species), with species overlapping their distribution in both types of forests. Disturbed habitats support 52 useful species of weedy plants and 29 species of useful ruderal plants. A total of 30 plant species used in the village were cultivated and six of them (*Crataegus mexicana*, *Cupressus lusitanica*, *Phaseolus coccineus*, *Prunus serotina* subsp. *Capuli*, *Rubus liebmannii*, and *Tagetes erecta*) occur also in wild populations in the forests surrounding the village (Fig. 3). Most plant species are used as fodder, human food, medicine, as well as commercial and fuel wood (Table 2). A total of 34 plant species (20 edible species, 7 species used as wood or fuel wood, 5 medicinal plant species, and 2 species of *Agave* used for the production of fermented beverage called "pulque," which results from the fermentation of the sap extracted from mature agaves) are sold in local and regional markets (Appendix 1).

Role of extraction and consumption of wild fruit in peasant subsistence. To complement their subsistence, the Mazahua families collect fruits of 17 species that are consumed throughout the year. Some of them are in addition sold in local and regional markets, allowing income; these are for instance the cases of blackberries (*R. liebmannii*), "capulín" (*P. serotina* subsp. *capuli*), and "tejocote" (*C. mexicana*), which are the species with the highest volume of fruits extracted, consumed, and

Table 2 Use form of plant species from Mazahua community Francisco Serrato

Use form	Number of species ($n = 213$ spp.)	Percentage (%)
Fodder	141	66.20
Medicine	59	27.70
Food	56	26.29
Ornamental	18	8.45
Fuelwood	16	7.51
Handcrafts	9	4.23
Construction	8	3.80
Soap	6	2.82

marketed in the closest city of Zitácuaro, Michoacán. Fruits of *R. liebmannii* were used by 90.5% of households, mainly fresh or prepared in flavored water, and in "atole," that is a traditional beverage prepared with maize dough and water, consumed for breakfast and dinner. It was estimated that on average 6 kg of blackberries are consumed per family per week during 12 weeks of the production season, between March and August every year. And nearly 19% of households of the village sell between 2.3 and 8.0 kg of blackberries per week in the market of the city of Zitácuaro. We estimate that 1.04 t of blackberries were consumed in the village per season and that 3.36 ton marketed per year (in total 4.40 ton harvested per year). Similarly, we calculate that the fruits of *C. mexicana* were consumed by 81% of the households interviewed. The average consumption was 1.0–0.20 kg per household per week during 12 weeks of the production season, estimating 1.82 ton consumed per year in the village.

All people of the village consume fruits of *P. serotina* fresh because they are highly appreciated for their flavor. These trees are commonly distributed in the borders of roads, gullies, small rivers, and homegardens. Fruits of *P. serotina* are available for 12 weeks from April to June. It is difficult to estimate the amount of *capulín* fruits used by the local population, since people not only collect them to consume at home, but also consume the fruits in the field, when carrying out agricultural or forestry activities. According to the interviews we carried out, the average consumption of fruit of this species was 1.8–0.4 kg per household per week, which allowed estimating a total of 4.04 ton per season by the whole community. Nearly 14% of the households sell fruits of *P. serotina*, on average of 10–12 kg of fruit per household per week, which allows estimating 3.43 ton of fruit harvested per season. Finally, the total amount of the *capulín* fruit harvested in the village is 7.47 ton.

Other fruits are commonly used in smaller amounts than those mentioned above, generally in the sites where they are collected. *Solanum appendiculatum*, *Cestrum tyrsoideum*, *Prunus brachybotrya*, *Comarosthaphylis longifolia*, the achenes of *Cirsium anartiolepis,* and acorns of *Q. crassifolia* are among the most relevant.

The Mazahua people use plants whose parts are consumed as greens, which are traditionally called "quelites." The quelites mainly used by the Mazahua are *Amaranthus hybridus*, *Brassica campestris*, *Chenopodium berlandieri*, *Dysphania ambrosioides*, *Cucurbita* spp., *Drymaria cordata*, *Galinsoga parviflora*, *Malva parviflora*, *Oxalis alpina*, *Phytolacca icosandra*, *Portulaca oleracea*, *Rorippa*

Fig. 3 Diversity of plant species used in the Mazahua Francisco Serrato Michoacán community: edible fruits of (**a**) *Prunus serotina*, (**b**) *Rubus liebmannii*, (**c**) *Crataegus mexicana*, (**d**) medicinal plant *Clinopodium macrostemum*, (**e**) plant use as a condiment *Dysphania ambrosioides*, (**f**) *Agave* sp., "quelites" edible plants, (**g**) *Amaranthus hybridus*, (**h**) *Chenopodium berlandieri*, (**i**) dry flowers and fruits of *Ternstroemia lineata*, and (**j**) tree trunks for firewood. (Photos: Berenice Farfán-Heredia)

nasturtium-aquaticum, *Solanum nigrescens*, and *Stellaria cuspidata* (Appendix 1). All of them are collected during the rainy season, except *R. nasturtium-aquaticum* that is available the year round.

Some collected plants are used to prepare beverages, one of the most important is *Clinopodium macrostemum*, whose leaves are boiled to prepare a stimulating infusion that is drunk in breakfast and dinner. Nearly 65.4% of the households interviewed consumed leaves of this species, with a frequency of one to 3 days per week, which is equivalent to 150–50 g per household per week, that is, nearly 1,078 ton in the whole town per year. The rest of the households used the infusion occasionally. The alcoholic beverage "pulque" is occasionally prepared and consumed with sap extracted from *Agave atrovirens* and *A. salmiana*.

Approximately 28.6% of the families interviewed used medicinal plants, mostly cultivated specimens. The volume of extraction of plants or plant parts for this purpose is low, therefore the impact seems to be insignificant. However, *T. lineata*, *Cuphea aequipetala*, *Equisetum* sp., and *Salvia lavanduloides*, which are collected from the wild, are commercialized and their extraction may be significant. For instance, the extraction of flowers of *Ternstroemia* spp. was motivated by their market value. A medium-sized tree of *Ternstroemia* spp. may produce 20–35 bags of dry flowers, weighing 150 g per bag, which is approximately $1.30 US dollars per bag and US $45.50 per tree. Unfortunately, the effect of this trade represents a risk since it motivates people to commonly cut the main stems of trees to collect flowers more easily. Although some trees survive and sprout, more than 20% die.

All households of the village cook with firewood. Some families have gas stoves but these are used only occasionally. The plants most commonly used as fuelwood are *Alnus acuminata* subsp. *arguta*, *Q. crassifolia*, *Q. laurina*, *Buddleia cordata*, *P. pseudostrobus*, *T. lineata*, *C. longifolia*, and *Baccharis conferta*. The average amount of fuelwood used per family per week is 196.9–45.3 kg, which means approximately 9.4 ton per year per household. The entire village consumes nearly 1,767 ton of firewood per year. Use of fuelwood is perhaps one of the major impacts on forest ecosystems, since unlike the timber extraction, obtaining firewood is a daily activity.

The raising of domestic animals is usually through free grazing in fields, but 9.5% of households gather wild plants to feed domestic animals managed in pens. The plant species used as fodder are particularly important in peasant economy as long as raising of domestic animals is a source of monetary income, labor animals, meat for direct consumption, and wool for textile manufacturing. At least 68 plant species are used to raise animals in the wild, but also some of them are collected to directly feed the animals in small stables. On average, they collect 5.5–1.25 kg of plants to feed three lambs per day, and 5.0–1.5 kg to feed one horse or donkey per day.

Environmental Units

The territory of the Mazahua community of Francisco Serrato is constituted by an area of 2,039.83 ha, of which 1,831.95 ha are under communal property regime, which represents 89.8% of the total area, and 207.88 ha under ejido property regime, which represents 10.2% of the total area.

Nearly one half of the territory of this community was covered with forests in the year 2000, whereas the other half of the territory was covered by transformed landscapes, including agricultural areas and shrub grasslands. However, during the period 2001–2003, a forest area greater than 350 ha was lost (more than 17% of the total area owned by the communal and ejidal properties), mainly on ejidal property, due to the intensive extraction of wood illegally in *Abies* forest (Fig. 4) (Ramírez et al. 2008; W.W.F. 2004). By the year 2020 nearly half of the forest area became transformed. By 2013 the transformed areas had secondary shrub vegetation, without clear ecological recovery processes (Salas 2013), and such condition is similar at present.

In the year 2000 the fir (pine-oak) forest covered 23.43% of the territory of the village and it was characterized by the dominance of *Q. laurina*, *P. pseudostrobus*, and the fir *A. religiosa*. Other arboreal species that occurred in this vegetation type were *P. brachybotrya*, *Alnus* spp., *Cornus disciflora*, *Oreopanax xalapensis*, and *Clethra mexicana*. Among the shrubs, *Cestrum nitidum*, *Solanum argentinum*, and *Arracacia rigida* were the most common, whereas in the herbaceous stratus *Solanum appendiculatum*, *Adiantum andicola*, *Tradescantia commelinoides*, *Salvia mexicana* and *Stachys* sp. were the most abundant.

The pine-oak forest occurs in elevations of 2,600–2,900 m. It covered 15.64% of the territory of the village and was dominated by *P. pseudostrobus* in association with *Q. laurina*, *A. acuminata*, *P. brachybotrya*, *B. cordata*, *C. disciflora*, and

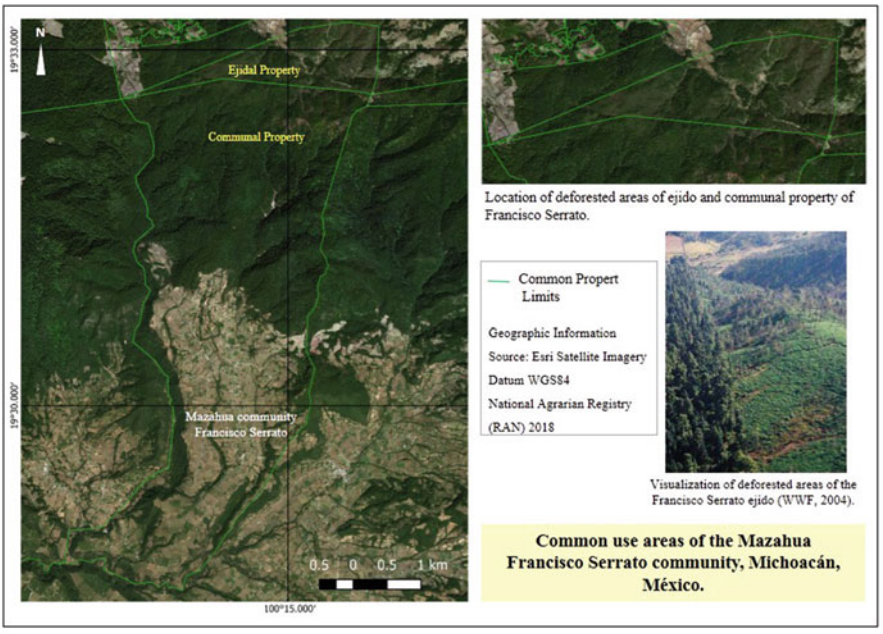

Fig. 4 Common use areas of the Mazahua Francisco Serrato community, Michoacán, México. Visualization of deforested areas of the Francisco Serrato territory

A. religiosa. Shrubs were represented by *C. thyrsoideum*, *A. rigida*, *S. argentinum, Fuchsia thymifolia*, and *Cirsium anartiolepis*, whereas the representative herbaceous plants were *Salvia fulgens*, *Salvia mexicana*, *Geranium seemannii*, *Lopezia racemosa*, and *Acaena elonganta*.

The pine-oak-alder forest covered approximately 5.24% of the territory in elevations between 2,500 and 2,720 m. It was dominated by *Q. laurina*, *Q. rugosa*, *Q. crassifolia*, *P. pseudostrobus*, *Populus* sp., *Alnus acuminata*, *T. lineata*, *Comarostaphylis discolor*, *C. longifolia*, and *Oreopanax xalapensis*. Among the shrubs, *Baccharis conferta*, *Euphorbia dentata*, *Fuchsia thymifolia*, *Cestrum nitidum*, and *Solanum argentinum* were the most abundant, whereas the main herbaceous plants were *Lopezia racemosa*, *Salvia mexicana*, and *Solanum appendiculatum*.

The riparian vegetation covered nearly 10.30% of the territory of the village, including gullies with pronounced inclination and small rivers. The arboreal stratus included *A. acuminata*, *B. cordata*, *Prunus* sp., *P. brachybotrya*, *T. lineata*, *Fraxinus uhdei*, *Q. laurina*, *C. mexicana*, *O. xalapensis*, and *P. pseudostrobus*. The shrubby stratus was dominated by *F. thymifolia*, *A. rigida*, *R. liebmannii*, *S. appendiculatun*, *Solanum nudum*, *Salvia elegans*, *Iresine diffusa*, *Salvia mexicana*, *Salvia fulgens*, *S. argentinum*, and *B. conferta*.

The agricultural areas comprise nearly 43.5% of the territory, mainly included fields of seasonal agriculture of maize and wheat, and fallow agricultural fields. The most common herbaceous plants occurring in agricultural areas were *Tradescantia commelinoides*, *Prunella vulgaris*, *Reseda luteola*, *Cyclanthera ribiflora*, *Acaena elongata*, *B. campestris*, *Phytolacca icosandra*, *Oxalis alpina*, *Piqueria pilosa*, *L. racemosa*, *Lepidium virginicum*, *Melampodium divaricatum*, *A. hybridus*, *Galinsoga parviflora*, *Simsia amplexicaulis*, *Lupinus elegans*, *Jaltomata procumbens*, *Gnaphalium attenuatum*, and *Bidens odorata.*

The scrub grasslands were in elevations between 2,500 and 2,900 m, covered nearly 6.66% of the territory of the village. Trees were absent and the dominant shrub was *B. conferta*. A high diversity of herbaceous plants were found, among them *Lepechinia caulescens*, *A. elongata*, *L. racemosa*, *R. nasturtium-aquaticum*, *Tradescantia commelinoides*, *Trifolium amabile*, *Tinantia erecta*, C. aequipetala, *Fragaria mexicana,* and *Mimulus glabratus.*

During the period from 2001 to 2003, the illegal logging decreased the forest area. The entire area of ejidal-owned *Abies* forest (207.88 ha) and 146.48 ha of communal owned *Abies* forest were lost, which represented a loss of 17.4% of the total area of the territory of the Mazahua community of Francisco Serrato (Table 3; Fig. 5).

Distribution of Useful Plants in the Environmental Units

A total of 72 useful plant species were recorded in the sampled sites, 52 of them (16 trees, 14 shrubs, and 22 herbs species) in forest areas and 20 in agricultural field. Plant species recorded included plants used as fodder, food, fuelwood, medicine, manufacture of tools, ornamental, and soap.

Table 3 Area by type of vegetation and deforested area during the period from 2001–2003

Vegetation type	Total área (Hectares)	Total área (Percentage)	Deforested area in 2001–2003 (Hectares)	Total área (Percentage)
Agricultural areas	897	43.97		
Fir forest	477.9	23.43	207.88 Ejidal property	10.1
			146.48 Comunal property	7.1
Pine-oak (Alder) forest	319	15.64		
Riparian vegetation	210.2	10.30		
Scrub grasslands	135.8	6.66		

The riparian vegetation had the highest richness and diversity of useful plant species, including the 53.8% of the useful plant species that recorded 62.5% of the useful trees, 78.6% of the useful shrubs, and 31.8% of the useful herbs in all units sampled. However, access to plant resources of this vegetation types is relatively difficult since it mostly occurs in areas of abrupt terrain.

The different types of pine-oak forests have been the most important areas supplying plant resources to the Mazahua of Francisco Serrato since they covered nearly one-third of the territory of the village, and density and biomass of useful species in this vegetation type is higher than in others. The association of pine-oak-fir, for instance, included 46.2% of the useful plant species recorded (50% of the useful trees, 57.1% of the useful shrubs, and 36.3% of the useful herbs recorded in all units sampled), covering 17.8% of the surface of the territory of the village. However, because of the abundance of important timber producing species *P. pseudostrobus* and *A. religiosa*, this vegetation type has been the area with the highest intensity of timber extraction and, for this reason, the abundance of non-timber products in this vegetation type offered in the year 2000 possible options for sustainable use, but after their severe transformation the recovery of the forest is a priority. The different types of pine-oak forest included also a broad spectrum of useful plants in areas close to the settlements of the village and, therefore, it was an area of easy and continuous access. Unfortunately, this area has been under continuous extraction of wood and fuelwood and, therefore, densities of timber species such as *P. pseudostrobus*, *Q. laurina*, *Q. crassifolia*, *Q. rugosa*, and *A. acuminata* are relatively low (Table 4).

Useful trees and shrubs were relatively scarce in the pine-oak-alder forest, but in this vegetation type species of useful herbs were rich, including 50% of the useful herbs recorded (Table 4).

The riparian vegetation supplies more than 60% of useful plants for different purposes, including all edible plants recorded, whereas the pine-oak forest supplied more than 60% of edible plants.

The agricultural areas were also important reservoirs of useful noncultivated plants. Corn fields contained nearly 30% of useful plants, especially weedy plants. Among the weedy plants, the “quelites” were consumed from June to August. In addition, 13 species used as fodder gathered to feed chickens were available in maize

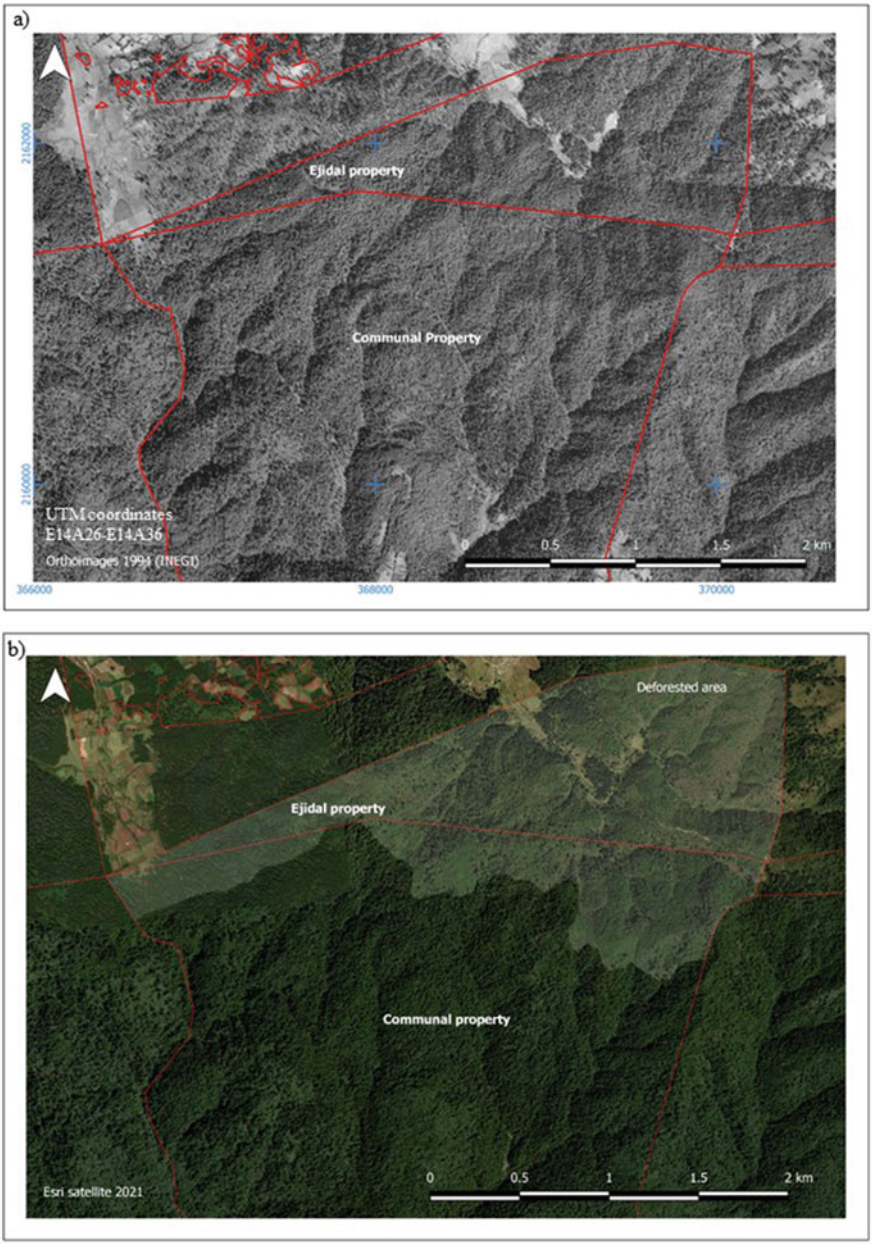

Fig. 5 Deforested area in the ejidal and communal property of the Francisco Serrato community: (**a**) forest area in 1994, (**b**) deforested area in the period 2001–2003

fields. The wheat fields contained nearly 15% of the useful species. In the fallow agricultural fields plant resources were mostly fodder and these were commonly used for free raising cattle, sheep, and donkeys.

Table 4 Vegetation types their extent within the village of Francisco Serrato, and the pooled diversity of trees and shrubs and herbs

Vegetation type	Area (ha)	Percentage of the total	Diversity of trees and shrubs		Diversity of herbs Shannon H
			Shannon H	Simpson 1/D	
Fir (Pine-oak) forest	477.9	23.43	0.950	6.794	1.041
Pine-oak (alder) forest	319	15.64	1.004	6.307	0.778
Riparian vegetation	210.2	10.30	1.114	10.474	0.903
Scrub grass area	135.8	6.66	0.061	1.055	1.000
Agricultural fields	897	43.97	0.000	0.000	1.342
Total area	**2,039.9**	**100**	–		–

Temporal Availability of the Main Useful Plants

Perennial plants used as fodder, mainly shrubs, are available throughout the whole year, but annual plants are available mainly during the rainy season from June to September, and some of them until October. Availability of medicinal plants is variable, depending on the plant part used. For instance, perennial plants whose cortex is the useful part, as it is the case of *B. cordata*, are available the year round; it is also the case of perennial plants whose leaves continually produced are the useful part, as in *S. argentinum*, *Salvia lavanduloides*, or *Lippia umbellata*. However, some species produce seasonally useful products, as in the case of the flowers of *T. lineata*, available from November to January or, in the case of annual plants, the season they are available, as in the case of *G. attenuatum*, *Tagetes lucida*, and *Verbena litoralis*, among others. Availability of edible plants depends on the production season of the edible parts. Some of them are available throughout the year as are the cases of *Stellaria cuspidata* and *Salvia fulgens*. In these cases, the whole plant and the stems, respectively, are consumed. Availability of edible fruits generally occurs during relatively short times, but there is availability of products of at least one species the year round. Greens or quelites are seasonally available, mainly during the rainy season, but others such as *R. nasturtium-aquaticum*, which are aquatic plants, are available in January and February. In the agricultural areas, availability of herbaceous plants is restricted to the growth periods of crop plants in the case of corn fields from April to September whereas in the case of wheat fields from August to January. *B. campestris*, *A. hybridus*, *O. alpina*, and *J. procumbens* are available from June to August, when staple crops have not been still harvested, and for that reason these plants complement importantly the diet of local people. Plants used as fuelwood are available the whole year.

Conclusions and Perspectives

The Mazahua system of classification and nomenclature of plants follows the general principles of classification presented by Berlin (1992), which consists of hierarchical systems with inclusion levels, which include not only plants with some form of use, but also unused plants (Berlin 1992).

In general, the Mazahua classification system is based on the affinities of morphological characteristics, habits and habitats, independently of their cultural importance.

The Mazahua use a wide spectrum of resources, we recorded 213 species of plants that use them in their daily life. This pattern of diversified use of plant resources is consistent with the pattern defined as "multiple utilization of natural resources and ecosystems" that generally characterizes the form of subsistence of indigenous communities in Mesoamerica (Farfán-Heredia et al. 2018a, b; Rangel-Landa et al. 2016; Blancas et al. 2010; Casas et al. 1994, 2014; Caballero et al. 1998; Caballero and Mapes 1985; Toledo et al. 1978).

The Mazahua include wild plants and fruits in their diet. For instance, the "quelites" are the non-crop plants mostly used as food. These plants are available during the period from June to August, beginning the rainy season, at the time when the basic grains have just been sown and the harvest of the previous year has decreased. During this period, wild and weedy edible plants play an important role in the diet of Mazahua households.

Agriculture is not sufficient to satisfy the needs of Mazahua households studied. To compensate, they obtain a significant number of species and biomass of products for both direct consumption and commercialization. They regularly sell wild fruits such as *P. serotina* and *R. liebmannii*, to buy basic grains. They also collect and consume wild edible plants to complement their diet.

The volume of extraction of medicinal plants and the impacts due to this activity are mostly insignificant. However, the destructive form of extraction of *Ternstroemia* spp. is relevant. The occurrence of 150 individuals of *Ternstroemia* spp. per hectare in riparian vegetation was recorded, covering an area of 210 ha of the territory of the community. Almost 30% of these trees have signs of having been cut for harvest, with evidence of buds that arise from the main trunk. This practice endangers the populations of *Ternstroemia* since nearly 20% of the trunks tamed do not regenerate, which indicates the need to stop this form of extraction by constructing local regulations, designing appropriate gathering tools, and conducting environmental education programs.

The species of plants used as firewood are indispensable in the local economy, since all people use firewood for cooking, as well as a source of monetary income. According to the people interviewed, the extraction of firewood does not involve the cutting down of trees, but only the harvesting of dead branches and trees. Nevertheless, the total annual consumption of fuelwood is high and the promotion of strategies for more efficient consumption of fuelwood could contribute to the reduction of wild fuel consumption. Programs of efficient stoves may be highly helpful for reaching successfully such purpose.

Forage plants are important in the peasant economy, as raising domestic animals is a source of meat, work animals, and monetary income. Therefore, designing sustainable patterns of livestock raising, including silvo-pastoralism and agro-silvo-pastoralist systems are a priority.

"Quelites" and wild fruits are a direct source of food and monetary income throughout the year. For maintaining or increasing their availability, it is essential to design sustainable management strategies of use, production, and commercialization of non-timber forest.

For maintaining sustainable resource management strategies, it is necessary to analyze the spatial and temporal availability of plants and extraction rates to ensure their long-term maintenance. For instance, we documented that the spatial availability of *P. serotina* is 126 individuals per hectare in the riparian vegetation, covering 210 ha of the territory of the village. This species produces on average 6,200–447 fruits per adult tree, equivalent to 11.4–0.8 kg of fruits per tree, and approximately 302.6 ton available in the village. Considering that people consume nearly 7.47 ton per year, the ecological information suggests that the impact of harvesting these fruits is relatively low and that it would be possible to increase this practice to develop alternative commercial products. In a similar way, we estimated that approximately 34.18 ton of fruits of *C. mexicana* were produced annually in the village, but people consume 1.82 ton per year. However, *R. liebmannii* produces nearly 6 ton of fruit per year and people ingest 4.4 ton yearly, nearly 70% of the total production. This information suggests that the extraction rate could affect the maintenance of the populations of this species in the long term.

We estimate that the agricultural area of the village, which covers an area of 902 ha, produces 23.6–46 ton of the "quelites" *B. campestris* and *A. hybridus*, respectively; and that the annual consumption of these plants was 4.3 ton and 0.9 ton, respectively, which indicates that the harvest rates of these resources are relatively low.

In this study, we inventoried information on use forms, distribution, abundance, and availability of non-timber plant resources with a potential for exploitation that allows the social and economic development of the community. This information may be a basis for establishing strategies for extraction, processing, and marketing of these products in a sustainable way, for the diversification of the use of wild resources in the community.

Although in the current scenario of dynamics of forest cover loss, the wide range of non-timber forest resources is not considered (Fig. 4). Those that provide local means of subsistence to peasant communities, for food, for health, as biofuels, as ritual and ceremonial elements, for the elaboration of utensils, crafts and for small-scale livestock. In addition, forests are the setting to generate and transmit traditional knowledge, worldviews, ecological ethics, and traditional management practices from the worldview of indigenous and peasant communities.

The information reported has been the product of the articulation of different methods and techniques of research, description, systematization, and data analysis, under the focus of several disciplines such as botany, floristic, ecology, cartography,

sociology, and linguistics, all of them around the basics of ethnobotany. Such a multidisciplinary methodological framework allowed having a set of elements and aspects around the plant resources that have allowed, in the first instance, to describe the knowledge, use, and management of the plant resources of the Mazahua. In addition, to note the importance of the units of vegetation in terms of diversity, density, and biomass of non-timber plant resources used by the community and susceptible to use in the short, medium, and long term, all these information are in relation to the dynamics of consumption and temporary availability of plant resources. These elements of analysis appear to provide criteria for designing sustainable forms of using both resources and ecosystems (Bray et al. 2003).

Given the processes of change in current ecosystems, it is of great value to have information on ecological, cultural, and economic aspects of ecosystems, which contribute to the subsistence of people from rural communities, recognizing the role of timber, non-timber forest resources and ecosystem services as fundamental to human well-being and the maintenance of diversity and biocultural heritage.

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Appendix 1 Useful plants of the Mazahua village of Francisco Serrato. Habitats: 1 = ruderal; 2 = agricultural areas as weeds; 3 = agricultural area as crops; 4 = pine-oak forest; 5 = pine-oak-fir forest; 6 = riparian vegetation; 7 = shrub and grassland. Voucher specimens correspond to Farfán-Heredia collection numbers

Plant family	Species	Habitat	Mazahua name	Use	Voucher
Pteridophyta					
Aspleniaceae	*Asplenium monanthes* L.	4, 5, 6	***ngüeí***	Ornamental, medicinal	9
Dryopteridaceae	*Polystichum distans* Fourn.	2, 6	***ngüeí***	Ornamental	342
Polypodiaceae	*Pleopeltis mexicana* (Fée) Mickel & Beitel	4, 5	***ngüeí***	Ornamental	169
	Polypodium madrense J. Sm	4	***ngüeí***	Medicinal	20,173
Pteridaceae	*Adiantum andicola* Liebm.	4, 5, 6	***ts'ibankjua***	Medicinal	8
	Cheilanthes chaerophylla (M. Martens & Galeotti) Kunze	4, 5	***ts'ingüeí tr'eje***	Ornamental	200

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
Monilophyta					
Equisetaceae	*Equisetum* sp.	2, 6	***kox'y***	Medicinal	122
Coniferophyta Cupressaceae	*Cupressus lusitanica* Mill.	3, 5	***zez'ojnu***	Handcrafts, construction, fuelwood, ornamental	108
Pinaceae	*Abies religiosa* (Kunth) Schltdl. & Cham.	5		Construction, firewood	349
	Pinus hartwegii Lindl.	4, 5	***xivatí***	Construction, firewood	76
	Pinus leiophylla Schiede ex Schl*tdl.* & Cham.	4	***xivatí***	Construction, firewood	198
	Pinus pseudostrobus Lindl.	4, 5	***xivatí***	Construction, firewood, medicinal	93
Magnoliophyta					
Magnoliopsida Amaranthaceae	*Iresine diffusa* Humb. & Bonpl. ex Willd.	6	***ts'inguitz' ajna***	Fodder	71
	Amaranthus hybridus L.	2		Food, fodder, medicinal	Photo record
Apiaceae	*Arracacia rigida* J.M. Coult. & Rose	4, 5	***z'apzantreje***	Medicinal, fodder	42
	Eryngium columnare Hemsl	5	***nrab'idyi***	Fodder	24
Apocynaceae	*Vinca major* L.	2		Ornamental	121
Araliaceae	*Oreopanax xalapensis* (Kunth) Decne. & Planch.	5		Fodder	357
Asteraceae	*Ageratum corymbosum* Zuccagni ex Pers.	2, 4		Fodder	311
	Archibaccharis schiedeana (Benth.) J.D. Jacks.	2, 4		Fodder	279
	Archibaccharis hirtella (DC.) Heering	2, 5		Fodder	316
	Artemisia ludoviciana Nutt.	2, 4	***j'mipzi***	Medicinal	127
	Baccharis conferta Kunth	1, 5	***mb'axu***	Fodder, handcrafts, fuelwood	14
	Baccharis pteronioides DC.	1, 2, 4	***mb'axu***	Fuelwood, handcrafts	111
	Barkleyanthus salicifolius (Kunth) H. Rob. & Brettell	5	***dyecha***	Fodder	45
	Bidens odorata Cav.	1,2, 4	***ñinch'ujnu***	Fodder	283

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Brickellia squarrosa B.L. Rob. & Seaton	4	***mb'opziño***	Fodder	56
	Cirsium anartiolepis Petr.	5	***nrrab'idyi***	Food, fodder	91
	Conyza coronopifolia Kunth	2, 4		Fodder	163
	Erigeron galeottii (A. Gray) Greene	2, 4	***nrrab'a***	Fodder	144
	Erigeron karvinskianus DC.	4	***nrrab'a***	Fodder, medicinal, ornamental	180
	Erigeron longipes DC.	4	***nrrab'a***	Fodder	179
	Ageratina areolaris (DC.) Gage ex B.L. Turner	5	***nupziño***	Fodder	299
	Eupatorium sp.	5	***kjoñizha***	Fodder	22
	Eupatorium sp. 1	5	***pepziño***	Fodder	4
	Galinsoga parviflora Cav.	2, 4		Food, fodder	323
	Gnaphalium attenuatum DC.	5	***gordolobo***	Medicinal	Photo record
	Gnapahlium sp.	5	***gordolobo***	Medicinal	Photo record
	Jaegeria hirta (Lag.) Less.	2, 4		Fodder	322
	Melampodium divaricatum (Rich. ex Rich.) DC.	4, 6	***nrrab'a***	Fodder, medicinal	214
	Melampodium perfoliatum (Cav.) Kunth	4	***nrrab'a***	Fodder	293
	Pinaropappus roseus (Less.) Less.	4	***pob'a***	Fodder	113,162
	Pinaropappus sp.	5	***pob'a***	Medicinal	43
	Piqueria pilosa Kunth	4		Fodder	195
	Roldana hederifolia (Hemsl.) H. Rob. & Brettell	5	***mb'opziño***	Fodder	363
	Roldana albonervia (Greenm.) H. Rob. & Brettell	4, 5	***mb'opziño***	Fodder	21
	Roldana angulifolia (DC.) H. Rob. & Brettell	2, 4	***mb'opziño***	Fodder	334
	Roldana barba-johannis (DC.) H. Rob. & Brettell	1. 2, 4, 5, 6	***mb'opziño***	Fodder	344
	Roldana suffulta (Greenm.) H. Rob. & Brettell	4	***mb'opziño***	Fodder	361

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Senecio callosus Sch. Bip.	2, 4, 6	***k'axtr'u nrranj'a***	Fodder, ornamental	343
	Senecio stoechadiformis DC.	1, 4	***k'axtr'u nrranj'a***	Fodder	295
	Senecio toluccanus DC.	4, 5	***k'axtr'u nrranj'a***	Fodder, ornamental	27
	Sigesbeckia jorullensis Kunth	4		Fodder	346
	*Simsia amplexicaulis (*Cav.) Pers.	2, 4		Fodder	326
	Stevia lucida Lag.	5	***pe'pziño***	Fodder	25,49
	Stevia serrata Cav.	1, 4	***nrr'axikjua***	Fodder	296
	Stevia origanoides Kunth	4	***pe' pziño***	Fodder	297
	Stevia subpubescens Lag.	4, 6	***pe'pziño***	Fodder	13,288
	Tagetes erecta L.	2, 3, 4, 7	***k'axtr'u nrranj'a***	Ornamental, medicinal, fodder	192
	Tagetes lucida Cav.	1, 2, 4	***k'axtr'u nrranj'a***	Medicinal, fodder	385
	Tagetes micrantha Cav.	4, 7	***k'axtr'u nrranj'a***	Medicinal, food	337
	Taraxacum officinale F.H. Wigg. *Taraxacum officinale* (L.) Weber ex F.H.Wigg.	1, 2	***ts'ik'axtr'un ajnua***	Fodder	149
	Verbesina klattii B.L. Rob. & Greenm.	5	***pe'pziño***	Fodder	359
Betulaceae	*Alnus acuminata* subsp. *arguta (*Schltdl.) Furlow	5, 6	***mb'e'e***	Handcrafts, fuelwood, construction	54
	Alnus jorullensis Kunth	5, 6	***mb'e'e***	Handcrafts, fuelwood, construction	159
Brassicaceae	*Lepidium sordidum* A. Gray	2	***ts'inrroí***	Fodder	106
	Lepidium virginicum L.	2	***ts'inrroí***	Fodder	307
	Rorippa nasturtium-aquaticum (L.) Schinz & Thell. *Rorippa nasturtium-aquaticum (*L.) Hayek	6		Food, commerce	33
	Brassica rapa L.	2		Food, fodder, medicinal, commerce	Photo record
	Brassica campestris L.	2		Food, fodder	480

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
Buddleiaceae	*Buddleia cordata* Kunth	5	***xij'ta***	Fodder	48
Cactaceae	*Opuntia ficus-indica* (L.) Mill.	3	***kij'i'i***	Food, medicinal, fodder	131
Campanulaceae	*Lobelia laxiflora* Kunth	1, 5		Fodder	44
Caryophyllaceae	*Cerastium nutans* Raf.	4, 5	***ts'irr'oztejna***	Fodder	252
	Cerdia virescens Moc. & Sessé ex DC.	2, 4		Fodder	148
	*Drymaria cordata (*L.) Willd. ex Schult.	5		Food, fodder	32
	Drymaria excisa Standl.	4		Fodder	88
	Stellaria cuspidata Willd. ex Schltdl.	5		Food, fodder	92
Cistaceae	*Helianthemum glomeratum* (Lag.) Lag. ex Dunal	2, 4	***xits'ajna***	Medicinal, fodder	105
Clethraceae	*Clethra mexicana* DC.	2, 4, 5		Handcrafts, soap	333
Convolvulaceae	*Ipomoea* sp.	2		Ornamental	269
Cornaceae	*Cornus disciflora* Moc. & Sessé ex DC.	5	***nrrempe***	Fodder	247, 340
Cucurbitaceae	*Cyclanthera ribiflora* (Schltdl.) Cogn.	4	***zatrjo***	Soap, fodder	84
	Cucurbita argyrosperma C.Huber	3		Food, fodder, soap, medicinal, commerce	Photo record
	Cucurbita ficifolia Bouché	3		Food, fodder, commerce	Photo record
	Cucurbita moschata Duchesne	3		Food, fodder, soap, medicinal, commerce	Photo record
	Cucurbita pepo L.	3		Food, fodder, soap, medicinal, commerce	Photo record
Chenopodiaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	2	***Xujmu***	Food, fodder, medicinal, commerce	135
	Chenopodium berlandieri Moq.	2		Food, fodder, commerce	Photo record
Ericaceae	*Comarostaphylis discolor* (Hook.) Diggs	4	***trjoxu***	Fuelwood	478
		4	***penchoxu***	Food, fuelwood	59

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Comarostaphylis longifolia (Benth.) Klotzsch				
	Comarostaphylis discolor subsp. *rupestris* (B.L.Rob. & Seaton) Diggs	5	***trjoxu***	Fuelwood	70
Euphorbiaceae	*Euphorbia dentata* Michx.	1	***ts'inrroí***	Ornamental	287
	Euphorbia pulcherrima Willd. ex Klotzsch	3	***pascua***	Ornamental	Photo record
Fagaceae	*Quercus crassifolia* Bonpl.	4, 6	***Xilojo***	Handcrafts, food, fuelwood, medicinal	203
	Quercus laurina Bonpl.	4, 5	***xilojo***	Food, handcrafts, fuelwood	53
	Quercus rugosa Née	4, 5	***xilojo***	Food, handcrafts, fuelwood, fodder, medicinal, construction	51
Gentianaceae	*Halenia brevicornis* (Kunth) G. Don	7		Fodder	351
Geraniaceae	*Geranium seemannii* Peyr.	5	***xu'u***	Medicinal	39
Hydrophyllaceae	*Nama prostrata* Brand	4, 5		Fodder	80
	Phacelia platycarpa (Cav.) Spreng.	4, 5	***pzochavo***	Fodder	183
Lamiaceae	*Lepechinia caulescens* (Ortega) Epling	2, 5	***k'anrrejna***	Fodder	318
	Prunella vulgaris L.	4, 5	***k'anrrejna***	Fodder	237
	Salvia concolor Lamb. ex Benth.	5	***k'anrrejna***	Fodder	244
	Salvia elegans Vahl	1, 4	***k'anrrejna***	Fodder	282
	Salvia fulgens Cav.	5	***ts'imbarenzé***	Fodder	40
	Salvia carnea Kunth.	5	***ts'ixitz'ajna***	Fodder	245
	Salvia helianthemifolia Benth.	5	***k'anrrejna***	Medicinal, commerce	3
	Salvia lavanduloides Kunth	4, 6	***k'anrrejna***	Food, medicinal	73
	Salvia mexicana L.	2, 4, 5	***mb'opziño tr'eje***	Fodder	117
	Salvia sp.	6	***k'agrejne***	Fodder	208
	Salvia sp.	6	***ts'ik'agrejne***	Fodder	60
		4, 5		Medicinal	

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Clinopodium mexicanum (Benth.) Govaerts				Photo record
	Clinopodium macrostemum (Moc. & Sessé ex Benth.) Kuntze	4, 5		Medicinal	485
	Stachys coccinea Ortega	4	***mbarejnatr'eje***	Fodder	85
Lauraceae	*Persea americana* Mill.	3		Food, medicinal, commerce	Photo record
Leguminosae	*Astragalus lyonnettii* Barneby	4	***kjungo'o***	Fodder	186
	Dalea thouinii Schrank	1		Fodder, medicinal	290
	Desmodium aparines (Link) DC.	1	***pe'pziño***	Fodder	289
	Desmodium densiflorum Hemsl.	2		Fodder	146
	Lupinus elegans Kunth	5	***nrramona***	Fodder	97
	Phaseolus coccineus L. subsp. *coccineus*	3		Food	Photo record
	Phaseolus coccineus L. subsp. *formosus* (Kunth) Maréchal, Mascherpa & Stainier *Phaseolus coccineus* subsp. *formosus* (Kunth) Marechal & al.	6	***patol***	Food, fodder	261
	Phaseolus vulgaris L.	3		Food, commerce	Photo record
	Trifolium amabile Kunth	2		Fodder	321
	Vicia faba L.	3		Food, fodder	Photo record
Lythraceae	*Cuphea aequipetala* Cav.	5	***ngüechuxu***	Medicinal, food, commerce	36
	Cuphea jorullensis Kunth	4, 6		Medicinal, commerce	222
Malvaceae	*Kearnemalvastrum subtriflorum* (Lag.) D.M. Bates	1, 5	***nrr'akojnu***	Fodder	285
	Malva parviflora L.	1	***ts'inrr' axkojnu***	Food, ornamental, fodder, medicinal	305,306
Onagraceae	*Fuchsia thymifolia* Kunth	5		Fodder	13

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Lopezia racemosa Cav.	2, 4, 5	***pe'jnche***	Fodder	145
	Oenothera deserticola (Loes.) Munz	4, 5		Fodder	29,157
Oxalidaceae	*Oxalis alpina* (Rose) Rose ex R. Knuth	4, 6	***k'opi***	Food, fodder	213
	Oxalis sp.	4, 6	***ixí***	Fodder	68
Phytolaccaceae	*Phytolacca icosandra* L.	1, 2	***cangara***	Food, fodder,	124
Piperaceae	*Peperomia galioides* Kunth	1, 6		Soap, medicinal	331
	Peperomia quadrifolia (L.) Kunth	4, 6		Medicinal	348
Plantaginaceae	*Plantago australis* Lam.	3, 5	***lant'a***	Medicinal	151
Polygalaceae	*Monnina ciliolata* DC.	4, 5	***ts'ib'orencé***	Food, fodder	6
Polygonaceae	*Polygonum aviculare* L.	2, 4	***pziñotr'eje***	Fodder	139
	Persicaria lapathifolia (L.) Delarbre	1, 6		Fodder	308
	Polygonum sp.	2	***xu'u***	Medicinal	133
Portulacaceae	*Portulaca oleracea* L.	2		Food, fodder, medicinal	Photo record
Primulaceae	*Anagallis arvensis* L.	4	***pzochavo***	Fodder	95
Punicaceae	*Punica granatum* L.	3		Food, medicinal, commerce	Photo record
Ranunculaceae	*Clematis dioica* L.	4		Fodder	200
Resedaceae	*Reseda luteola* L.	2	***kjopziodyo***	Fodder	138
Rhamnaceae	*Ceanothus caeruleus* Lag.	4, 5	***ts'ik'agrejne***	Medicinal	174
	Frangula mucronata (Schltdl.) Grubov.	4, 6	***kjonz'a***	Fuelwood	75,138
Rosaceae	*Acaena elongata* L.	4, 5	***ñib'ota***	Fodder	18
	Alchemilla pringlei Fedde	2	***ñib'ota***	Fodder	147
	Alchemilla procumbens Rose	4, 6	***ñib'ota***	Fodder	230
	Crataegus mexicana DC.	3, 5	***xinpedyi***	Food, medicinal, commerce	99
	Eriobotrya japonica (Thunb.) Lindl.	2, 3	***níspero***	Food	Photo record
	Fragaria mexicana Schltdl.	5, 7	***muxatr'u***	Food, fodder	159
	Prunus brachybotrya Zucc.	5	***xínchoparu***	Medicinal	90
	Prunus domestica L.	3	***endrina***	Food, commerce	132
		1, 3, 4	***xinrrenz'e***	Food, commerce	86

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Prunus serotina subsp. *capuli* (Cav. ex Spreng.) McVaugh.				
	Prunus persica (L.) Batsch	3	***nrora***	Food, commerce	142
	Rubus liebmannii Focke	1, 3, 5	***xarrtr'u***	Food, commerce	23
Rubiaceae	*Bouvardia ternifolia* (Cav.) Schltdl.	4	***rnanta***	Fodder, medicinal	166
	Didymaea floribunda Rzed.	4, 6	***xitz'ajna tr'eje***	Fodder	61
Rutaceae	*Ruta chalepensis* L.	3	***lota***	Medicinal	134
Salicaceae	*Salix paradoxa* Kunth	4, 5, 6	***xijño***	Fodder, fuelwood	250
Scrophulariaceae	*Calceolaria mexicana* Benth.	5		Food	239,345
	Mimulus glabratus Kunth	5, 7		Food	240
	Penstemon campanulatus (Cav.) Willd.	5		Fodder	337
	Veronica americana Schwein. ex Benth.	5		Fodder	235
Solanaceae	*Cestrum nitidum* M. Martens & Galeotti	1		Ornamental	312
	Cestrum thyrsoideum Kunth	4, 5	***rr'oxululu***	Food	15
	Jaltomata procumbens (Cav.) J.L. Gentry	2, 4	***nrrempe***	Food, fodder	263
	Lycianthes rzedowski E. Dean	4	***onglaba***	Food, fodder	165,191
	Lycopersicon esculentum Mill.	3		Food, fodder, medicinal, commerce	Photo record
	Physalis volubilis Waterf.	4, 6	***ongo'o***	Food, fodder	210
	Solanum appendiculatum Dunal	4, 5	***nts'imbalixi***	Food, fodder	5
	Solanum cardiophyllum Lindl.	1, 6		Fodder	336
	Solanum argentinum Bitter & Lillo	5	***xíncho paru***	Medicinal	41
	Solanum nigrescens M. Martens & Galeotti	2, 5	***ongo'o***	Food, medicinal, fodder	123
	Solanum nudum Dunal	4	***xínchoparu***	Ornamental	211

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
	Solanum tuberosum L.	3		Food, commerce	Photo record
Symplocaceae	*Symplocos prionophylla* Hemsl.	6		Fodder	205
Theaceae	*Cleyera integrifolia (*Benth.) Choisy	5	***nrrensétr'eje***	Medicinal, food	1,332
	Ternstroemia lineata DC. subsp. *lineata*	4, 6	***mb'áza***	Medicinal, commerce	76
	Ternstroemia lineata DC.	4, 5	***mb'a'za***	Medicinal, commerce	47
Valerianaceae	*Valeriana barbareifolia* M. Martens & Galeotti	1	***ts'ir'ostejna***	Medicinal	292
	Valeriana clematitis Kunth	5, 6	***ts'ir'ostejna***	Medicinal	218
Verbenaceae	*Lippia umbellata* Cav.	4	***zalberia***	Medicinal	58
	Verbena gracilis Desf.	2, 4, 7	***kjestexu***	Fodder	164
	Verbena litoralis Kunth	2	***kjestexu***	Fodder	129
	Verbena recta Kunth	2, 4	***kjestexu***	Fodder	265
Violaceae	*Hybanthus attenuatus* (Humb. & Bonpl. ex Schult.) Schulze-Menz	6		Fodder	286,341
	Viola humilis Kunth	6		Fodder	150,193
Viscaceae	*Phoradendron velutinum* (DC.) Oliv.	4, 5	***búngu***	Fodder	2
Magnoliophyta Liliopsida Agavaceae	*Agave atrovirens* Karw. ex Salm-Dyck	3		Food, alcoholic beverage, commerce	PhR
	Agave salmiana Otto ex Salm-Dyck	3		Food, alcoholic beverage, commerce	PhR
	Furcraea parmentieri (Roezl) García-Mend.	3		Ornamental	PhR
Commelinaceae	Commelina elliptica Kunth.	4, 6		Fodder	320
	*Tinantia erecta (*Jacq.) Fenzl.	1		Fodder	294,325
	Tradescantia commelinoides Schult. & Schult.f.	4	***kjua'a***	Fodder	182,238
Cyperaceae	*Bulbostylis* sp.	2, 7	***nrreb'i***	Fodder	153
	Cyperus hermaphroditus (Jacq.) Standl.	7	***nrreb'i***	Fodder, medicinal	267

(continued)

Plant family	Species	Habitat	Mazahua name	Use	Voucher
Juncaceae	*Juncus effusus* L.	5, 6	***nrreb'i***	Fodder	31
Orchidaceae	*Malaxis macrostachya* (Lex.) Kuntze	4, 5		Ornamental	188
Poaceae	*Avena sativa* L.	3	***avena***	Food, fodder, commerce	Photo record
	Briza minor L.	1	***nrreb'i***	Fodder	313
	Cynodon dactylon (L.) Pers.	2, 7	***nrreb'i***	Fodder, medicinal	140
	Festuca breviglumis Swallen	2, 7	***nrreb'i***	Fodder	350
	Hordeum vulgare L.	3	***zebara***	Food, fodder, medicinal, commerce	110
	Muhlenbergia macroura (Humb., Bonpl. & Kunth) Hitchc.	5, 7	***nuxnrreb'i***	Fodder, medicinal	55
	Sporobolus indicus (L.) R. Br.	2, 7	***nuxnrreb'i***	Fodder	141
	Trisetum virletii E. Fourn.	5, 7	***nrreb'í***	Fodder	16
	Triticum aestivum L.	3	***nrreju***	Food, fodder, commerce	109
	Zea mays L.	3		Food, fodder, commerce	Photo record

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