Agroforestry Complexes in the Mountain Regions of Mexico

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Abstract

Mountain regions in Mexico represent outstanding environments where agroforestry processes are particularly important due to their complexity, difficult access, steep slopes, frosts, among other social and environmental aspects. From a historical perspective, mountain inhabitants are in a constant endeavor to develop management strategies to satisfy their needs. Their knowledge on surrounding ecosystems is constructed from the interaction's experiences though generations, evaluated through trial and error and constantly improved. This knowledge harbors a profound relevance as repository of biocultural strategies. Agroforestry systems are ongoing processes of deliberate human decisions, relating the articulation of wild, managed, and domesticated species at multiscale and multitemporal dimensions. These processes aim to derive ecological, economic, and social benefits integrating all these aspects in production, which in turn has

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important implications in terms of governance of the social units. In this chapter we show eight case studies from Mexico City, the State of Mexico, and the states of Puebla, Michoacán, Oaxaca, and Tlaxcala in temperate, subhumid, and semiarid conditions, at elevations ranging from 1300 to 2700 m, characteristic of the mountains of Central Mexico. From homegardens and collective gardens, slash and burn agroforestry, the several forms of multicrop milpas, profoundly and diversely interconnect with the wild surroundings; terraces and semi terraces in temperate, subhumid, and semiarid conditions are agroforestry systems that conform food landscapes. This chapter summarizes our views on these systems in the region.

Introduction

Steep hill lands, dry areas with long seasons without precipitation and low temperatures throughout the year, high biological diversity, ancient and complex human molded environments, are some of the predominant features of the mountain regions of Mexico (Boege 2008; Rojas 1991; Toledo and Barrera-Bassols 2008). From elevations about 1000 m it is possible to find these environments in Mexico. "Monte," as it is called in Spanish, in the conceptions of local ethnogeomorphology, has been and continues to be recognized as one of the main living spaces of original and other peasant's groups of rural México. It is in these spaces where peri-urban and urban vulnerable poor groups of numerous Mexican settlements are established. In environments at these elevations live a high number of local and migrant populations coming from the countryside to peri-urban areas of medium and large size cities of this country. In this context, the inaccessibility and the continual struggle to control soil erosion and landslides, maintenance of soil fertility, humidity, and diminishing the effect of frosts on agricultural systems are some of the most recurrent concerns of peasants groups since pre-Hispanic times until the present (Moreno-Calles et al. 2013, 2016, 2020; Wilken 1990). Borning and growing in the mountains, people learn from previous generations and continually innovate strategies to maintain the relationship with these environments. One of these strategies is the close interaction with the orographic, edaphic, climatic, and biological diversity of these spaces (Stepp et al. 2005), and it is in such context that agroforestry complexes make sense.

Agroforestry is conceptualized as the deliberate human articulation of wild and managed plants, animals, and fungi coexisting in spatial and time with crops and/or domestic animals in systems of agricultural management. Agroforestry systems integrate cultivated and/or domesticated elements in shrublands, temperate, and tropical forests with the purpose of obtaining ecological, economic, and social benefits (Moreno-Calles et al. 2014). Agroforestry worldwide is mainly practiced by farming families and is associated with landscape management practiced by original and peasant villages as well as those in urban and peri-urban contexts. Agroforestry complexes (including landscapes, systems, and agroforestry practices) integrate multiscale and multitemporal management strategies of biological and biocultural diversity that provide environmental benefits to human beings at local, regional, and global levels. With this management form, it is possible to generate

economic outcomes, strengthen food security, satisfy local and global needs, and environmental benefits mitigating effects of climatic phenomena like frosts, droughts, atypical rains, and wind gusts. Also, its components provide shade and protection, shaping the habitat of other useful species, favoring, maintaining, or increasing the formation of soil and maintaining or increasing its fertility, reducing erosion, and the effect of non-beneficial arthropods. Also these systems increase the control capacity of fire, maintaining hydrological benefits and in sum, constituting an important alternative for mitigation and adaptation to climate change (Jose 2009; Montagnini et al. 2015). In addition, these forms of management are a great scenario that articulates social learning, collective creation of knowledge, worldviews and practices, social and environmental values, and governance models of the social units who practice them and those of the social actors who are interested in them. These social actors include farmers, groups of native people, government entities, civil society, and international organizations (Toledo and Barrera-Bassols 2008). The questions that guided this chapter are: (i) Are there consistent patterns between the mountain regions of Mexico and agroforestry complexes? and (ii) What processes allow to understand these patterns? For analyzing these questions we analyze eight case studies that our group conducted in communities of Mexico City, the State of Mexico, and the states of Puebla, Michoacán, Oaxaca, and Tlaxcala in temperate, subhumid, and semiarid conditions.

Mexican Mountains, Biocultural Diversity, and Agroforestry Complexes

In Mexico, mountain areas are extensive and bioculturally relevant. The work of Boege (2008) analyzing the biocultural heritage of indigenous peoples of Mexico does not make a special emphasis on mountain areas, but it is possible to realize the special relationship between mountain regions, biodiversity, and cultural diversity in the biocultural heritage of Mexico. Previously, Wolf and Cirlot (1971) invited to observe the relationships between the relief, especially the slopes of the Gulf of Mexico and the Pacific to understand the distribution of the different cultures in Mesoamerica. The historian Bernardo García (2008) takes up this idea to analyze the conformation of the country's regions. The relationship between mountain areas, biodiversity, and cultural diversity is an important topic in Mexico.

For this chapter we based on the map of physical-geographic regions proposed by Cervantes Zamora et al. (1990), identifying that 47 of the 88 provinces that they propose can be considered as mountain landscapes. Mountain areas are of great importance to Mexico both for their distribution and for their relationship with the conformation of different environmental factors such as climate, vegetation, and the settlement and distribution patterns of the population of native peoples. Mountain areas are present in 28 of the 32 states of Mexico, the exceptions are the states of Tabasco, Campeche, Yucatan, and Quintana Roo. The provinces that can be considered as mountain areas are: Altos de Chiapas, Chiconquaco, Cordillera Costera del Sur, Depresión del Balsas, El Cabo, Escarpe Limítrofe del sur, Gran Meseta y Cañones Chihuahuenses, Gran meseta y Cañones Duranguenses, Gran Sierra

Plegada, Karst Huasteco, Lagos y Volcanes de Anáhuac, Lomeríos de la Costa del Golfo Norte, Mesetas y Cañadas del Sur, Mil Cumbres, Mixteca Alta, Neo volcánica Tarasca, Pie de la Sierra, Pliegues Saltillo Parras, El Burro, Cuatralba, Sierra de Guanajuato, Sierra de Jalisco, Sierra de la Paila, Sierra de los Tuxtlas, San Carlos, Sierra de Tamaulipas, la Giganta, Sierra La Cardona, Sierra de Baja California Norte, Sierra de la Costa de Jalisco y Colima, Sierra del Norte de Chiapas, Sierras Neo volcánicas Nayaritas, Sierras Orientales, Sierras y Llanuras Coahuilenses, Sierras y Llanuras Sonorenses, Sierras y Llanuras Tarahumaras, Sierras y Valles del Norte, Sierras y Valles de Oaxaca, Sierras y Valles Guerrerenses, Sierras y Valles Zacatecanos, Volcanes de Colima y Volcanes de la Costa Golfo Norte. The surface of these provinces is 980,852 km^2, that is, 49.93% of the surface of Mexico. Mountain areas contain 58 of the 61 climate types of Mexico since a factor of climatic variability is given by the altitude gradient. Thus, climate types are distributed in part following the elevation levels. The diversity of climates is also expressed in the diversity of vegetation types existing in these mountain areas. Based on the map of INEGI (2020b) series 6 on land uses and vegetation we found 135 different vegetation types for mountain areas. There are different types of tropical forests, like deciduous, subperennial, and perennial, different types of scrublands, as well as temperate forests like those dominated by oaks, pines, fir, sabinos, and mesophylous mountain forests. In many cases, the differences in vegetation may be present in a region in relation to altitude. Mountain areas are diverse in plants and animals. Different types of agriculture are also practiced in those areas, forming agroforestry complexes that include agroforestry terraces and semi-terraces, agroforestry fields where most of the richness of native maize, beans, squash, and edible native herbs (*quelites*) and local fruit species are preserved. Family and collective homegardens, agroforests where coffee, cinnamon, vanilla, pineapple, and cocoa are produced for income generation through local, regional, and global markets and agro-silvopastoral systems of colonial and recent origin. The seasonal agriculture practiced in the mountain areas has an extension of 111,561 km^2 (Series VI, INEGI 2020b), which represents 52.15% of the seasonal agriculture in the country. In the map of Fig. 1, we show the proposal by Stepp (2005) to explore the relationship between mountain areas and biocultural diversity according to the records of the data base "Sistemas Agroforestales de Mexico" (www.red-sam.org).

The Mountains, Their People, and History

There is a clear relationship between mountain areas and cultural diversity in Mexico for most of the original groups, except for the Yucatan peninsula and Tabasco. This settlement pattern, where the presence of indigenous groups coincide with the mountain areas, has its origin in geographic, ecological and historical processes. Three major processes in the history of Mexico influenced these areas, which are the Spanish conquest and colonization in the 16th to 18th centuries, the policies on indigenous lands and communities carried out by the laws of the Reform period in the nineteenth century, and the processes of land restitution and endowment of ejidos made by the Agrarian Reform in the 20th century. Taking these processes into account, we can

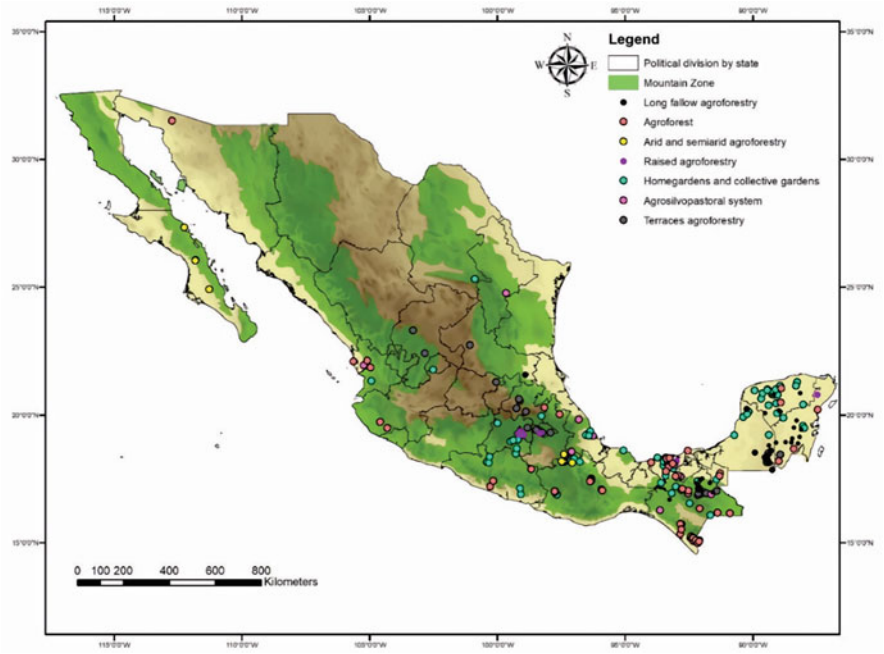

Fig. 1 Map of Mexico with the identified mountains and the points of the ethnoagroforestry systems registered in the database of the Network of Agroforestry Systems of Mexico (www.redsam.org)

see a coincidence between the regions of native peoples and the mountain areas, which have perhaps their explanation in what Aguirre Beltrán (1991) called refuge regions. In other words, throughout these processes, this population moved from their former territories to settle mountain territories where they could escape from the pressure of the colonial system, the dispossession of the haciendas, and other processes of deterritorialization, in order to maintain their ways of life. That is why in some cases it is not by chance that indigenous groups currently occupy the territories that were once of difficult access or distant. In these places, agroforestry systems and their benefits have a relevant meaning (Fig. 2).

Case Studies

Living in the Cold Mountains of Mexico Through Agrosilviculture

Agroforestry and Rituality in Ayuujk Montains

The municipality of *Tlahuiltoltepec* is located in the "Sierra Norte" of the state of Oaxaca, a region called in the local native *Ayuujk* language *Xaamkëjxp*, which means "cold place" or "place among clouds." Its territory comprises an altitude range between 1000 and 3400 m. The community located at the highest elevation is Santa María *Yacochi* (2332 m) where the fir (*Abies*) forest is the dominant type of

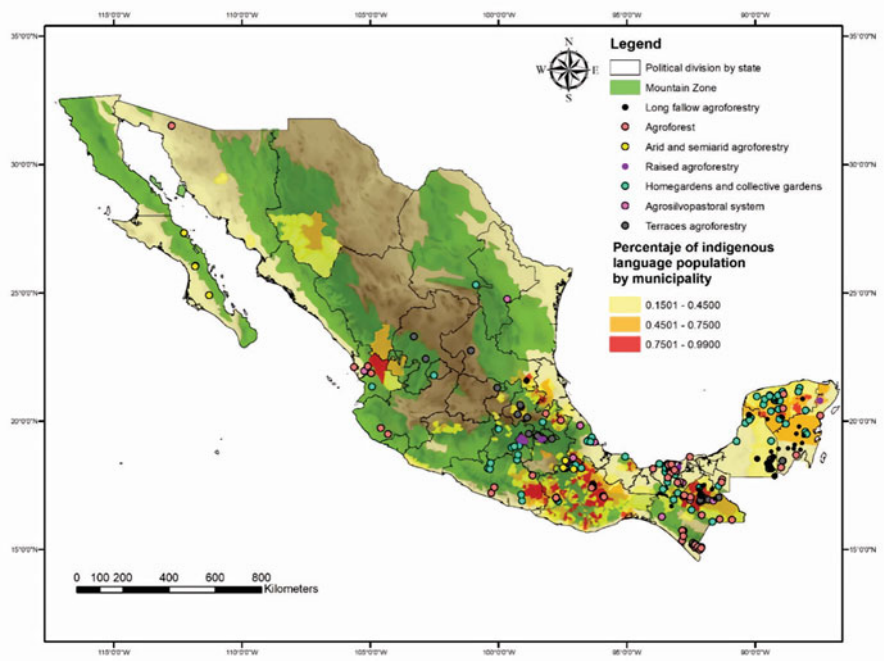

Fig. 2 Agroforestry complexes and indigenous peoples in Mexico. Only the Yucatan Peninsula and Tabasco are excluded from being considered mountainous areas

vegetation, in the middle elevations are the communities of *Tlahuiloltepec*, *Mosca,* and *Flores* (2090–2260 m) with temperate pine-oak (*Pinus – Quercus)* forest as dominant vegetation, and in the lowest elevation is the community of *Nejapa* (1800 m), where tropical deciduous forests is dominant.

The inhabitants of these communities select the places in mountains that will be used for cultivation, the trees, shrubs and herbs and other elements that will be removed from the land and the area that will be used for agriculture (Fig. 3a, b). Among the usually tolerated species in *Tlahuiltoltepec* we found ash trees (*Fraxinus udehi*), oaks (*Quercus* spp.), and "palo de águila" (*Alnus acuminata*), these species are valued for their timber and for construction and firewood together with pine trees (*Pinus* spp.).

The leaves of "palo de águila" are considered a good fertilizer, a natural dye is obtained, and is considered by people as a tree that attracts water "that tree has deep roots that make the water rise, that's why you find a lot around here" (Díaz 2017). The latter alludes to the hydraulic lifting that the tree performs since it has deep roots can reach the deep-water levels.

When the inhabitants of these localities have a spare landspace inside or in the premises of their houses, they also use it for plant culture. In both places, plot and house, the "milpa" system, consisting of maize (*Zea mays*), beans (*Phaseolus vulgaris*), and "chilacayote*"* (*Cucurbita ficifolia*) is stablished, in addition of growing fruit trees such as apple (*Malus domestica*), "tejocote*"* (*Crataegus mexicana*), "ocote*"* (*Pinus lawsonii*), and the shrub "chamizo" (*Baccharis conferta*).

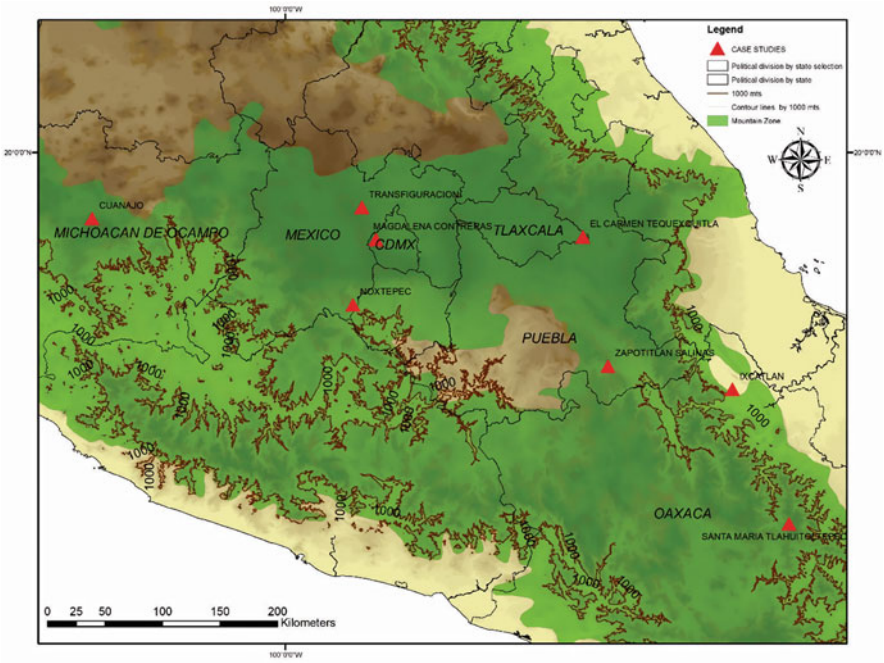

Fig. 3 Eight case studies are presented in Mexico City, State of Mexico (Transfiguración and Noxtepec), Puebla (Zapotitlán Salinas), Michoacán (Cuanajo), Oaxaca (Tlahuiltoltepec and Ixcatlán) and Tlaxcala (Carmen Tequexquitla) in temperate, sub-humid and semi-arid conditions in the altitudinal ranges since 1300 to 2700 masl

The relevance of species like "palo de águila" is expressed where it is spatially located and in the wealth of agroforestry practices in which it is found. For instance, *Alnus acuminata* is tolerated for planting maize and without no specific spatial arrangement, they can be located at the top, bottom, middle or in the bank of plots, or at the end of a maize row. Although these trees need time to be harvested, their use is limited to the time it takes for the tree to grow and the number of trees they have in their land or house is directly related to the areas they manage and own. These areas are relatively small and can stand only three to five trees. The decision to maintain few or several trees is taken based on their needs, such as using a large part for plant culture, a pen for domestic animals or the construction of a house.

A close, ancient and ritual connection with the mountains, the forests, and the conception of the wild, is clear, and without its complementarity and antagonism, agriculture would not be conceived. Rituals related to agroforestry management and the connection that farmers have with nature are carried out in the mountain or the hill. When lands are cleared, people perform rituals directed to ask nature its permission to clear and to plant; mescal is offered to nature, otherwise peasants could suffer a bad augury. Living in the mountains also means that a collective organization of the agricultural activities is needed in order to reduce the effect of inaccessibility. This organization requires the necessary strength to achieve the essential transformations

and maintenance for its subsistence, an example of this is the planning to start sowing. The family that will sow invites other people, family or friends, they have to provide food all along the working day, "tepache" and mescal; in addition, they commit to help sowing the land of those people that helped them. Sowing starts early with breakfast, then a ritual is performed on the land to sow, the performance of this ritual will depend on each family. The way of sowing by the *Ayuujk* people is practiced as follows: people are placed vertically in rows, the first one starts sowing and leaves 60–80 cm between each hole where he sowed. The person below starts sowing a moment later to the first and will sow the parallel row below using the spaces left, being careful not to pass the first one, as well as the other people who are sowing. When reached the row end, the last person will return taking first place to sow, the others will follow his footsteps. This practice has been transmitted throughout generations. "Mano-vuelta" (hand and return) is practiced, it consists in the commitment of returning the favor of participation in sowing, without any economic retribution. The performance of the ritual involves the offering of a fowl, the seeds to be sown, mescal, "tepache" and the "coas" (ancient Mesoamerican instrument used for sowing). The ritual begins with a prayer, in *Ayuujk* language, invoking a deity that represents nature and wellness, the so-called Rey Konk, to ask for his permission to sow, for the seeds to germinate, for good augury in all the labors and good harvest. A rooster is sacrificed with a machete, its blood is scattered on the soil and maize seeds as a sign of fertility. Its head is then buried by the landowner, near a specific tree or in the center of the field, then mescal and tepache are poured to the ground three times, to feed the earth. Then mescal is distributed among those who will participate in sowing, three drops most be poured on the ground before they drink. Finally, the rooster's feathers are settled around the place where its head was buried, then the sowing begins (Fig. 4).

Fig. 4 Agricultural ritual performed by the family of Doña Catalina on her plot, a rooster was sacrificed and its blood was used to water the seeds that will be used for planting, mezcal and tepache are offered to the land and then among the participants who will sow. (Photo by the authors)

Every year in December, the *Ayuujk* people make a visit to a sacred mountain called "*Cempoaltépetl"* to show their appreciation for the wellness of the year, for the harvest, for the good health and for the work done. This visit is also made during the first days of the new year to ask for health, work or a good harvest. This journey takes 3 h, the people walks up to the highest point of elevation of the mountain (3420 m). The *Ayuujk* also draw upon the "*xëmaapyë*," wise people that serve as fortune tellers, who help people to prepare the offerings they must present to the mountain to deal with specific illness and the commitment with the mountain. Some people don't search fortune tellers help because they know what they have to offer, but then when people encounter with a snake or dreams with it, they know it is a sign that a ritual or offering is needed to be in harmony with the mountain and then they recur to the fortune teller to ask for his guidance.

Homegardens and Ornamentality in Cuanajo, Michoacán

The town of *Cuanajo* is in northern Michoacán. In *Purépecha* (the original language), it means "place of frogs." The valley of Cuanajo is located at 2320 m, surrounded by mountains that surpass 3300 m, the main vegetation types are temperate forests dominated by the associations of *Pinus-Quercus*, *Pinus, Quercus-Pinus* and *Abies religiosa* (Caballero 1982; Farfán-Heredia 2019). The area has undergone major transformations because of excessive logging (a process that began since the conquest) and agriculture. In recent years, the increase of intensive cropping of some crops like avocado (*Persea americana*), blackberry (*Rubus ulmifolius*), and strawberry (*Fragaria vesca*) in the surroundings have also contributed to deforestation. The resulting scenario is a heterogeneous matrix composed by crop areas and forest remnants. *Cuanajo* is under a process of urbanization and transformation. In the community, the inheritance and distribution of land to male children is a tradition, so when a son begins his own family, he is granted a space of land in which to live. This aspect has had a direct impact on the accommodation and use of space. Formerly, the existence of an agroforestry system called "*ekuaros"* or family gardens as a productive space for species valued as food, medicinal, forage, ornamental, incomes security, textile, tannins, timber, and aromatic uses (Alarcón-Chaires 2009). Today, within the locality, family gardens or "patios" are mostly recognized as areas with similar purposes to that of the "*ekuaro*." *Ekuaros* are described as adjacent areas to the house room composed by different useful plant species, which are under incipient management. Within the patios of this town, it is common to find introduced fruit trees that tolerate cold and drought such as *peaches* (*Prunus persica*), *lemons* (*Citrus x limon*), *oranges* (*Citrus x sinesis*), *nísperos* (*Eriobotrya japonica*), *manzana* (*Malus domestica*), chabacano (*Prunus armeniaca*), pear (*Pyrus communis*), and membrillo (*Cydonia oblonga*), and also native species such as avocado (*Persea americana*), capulín (*Prunus serotina*), tejocote (*Crataegus mexicana*), guava (*Psidium guajava*), and chirimoya (*Annona cherimola*), other common crops are chile perón (*Capsicum pubescens*) and chayote (*Sechium edule*). Medicinal plants are also cultivated. Predominance of ornamental plants, in terms of abundance and richness, is evident. Improvised pots, like food cans and paint buckets, are abundant in the patios, these are used to cultivate

ornamental plants, highlighting the diversity of succulent plants. The cultivation and propagation of these plants is encouraged because they are used to trade or barter in neighboring markets. Pátzcuaro barter market stands out, a market with *Purépecha* tradition frequented by the inhabitants of towns nearby. The importance of ornamental plants is related to their economic and commercial value in response to demand and in coherence with an economy based on the use value and the diversification of goods produced.

The presence of ornamental plants in house rooms is closely linked with the perception of femininity in Cuanajo. A well-kept house should be adorned and embellished with many flowering plants. Likewise, admiration for these spaces increases when the diversity and uniqueness of the species is greater. An ancient relationship with this ornamental diversity has been documented, we can refer to this connection as ornamentality, seen as a long-term and continuous relationship or process in a territory. This interaction favors landscapes, spaces, species and cultivars for the purpose of decoration, contemplation, beautify, influence mood, and make day to day bearable. To remember the colors, smells and shapes is a remembrance of mothers and grandmothers, because in this community, flowers are a matter for women, and it is considered a luxury and a way to provide economic incomes, food or material resources through exchange. Therefore, women are always looking to increase their collection of ornamental plants, adding those that they consider scarce or unique or, conversely, other plants that have become very popular due to their novelty. One of the most relevant strategies for this purpose is the existence of a living exchange network of ornamental plants, in which women look for new additions or to recover lost cultivars. This network is supported by women and their patios and "ekuaros" and the regional markets. The heterogeneity mountain can provide color palette or the adjacent areas, the other patios or *ekuaros* or the markets exchange. A particular group of plants occuring in patios that stands out for its beauty and diversity is a group of cacti called "teresitas" and "pitayitas," species of the genera *Disocactus* (*D. phyllanthoides* and *D. speciosus*), *Epiphyllum*, *Selenicereus,* and hybrids between genera and species (*Disocactus x hybridus; Disocactus x Epiphyllum,* and *Disocactus x Selenicereus*) (Fig. 5).

Ornamental species management differs to the management of other species present in this system. They are planted and cultivated in pots, an aspect that allows their mobility, transport and the colonization of new spaces like roofs and walls; the propagation method is mostly asexual by means of cutting and shoots; and its support is given from two main inputs, soil and water. The soil is gathered from the forest mulch of the mountains that surround the community. Ornamentality has a different meaning than ornamentalization, a process registered in other homegardens in Mexico, this concept refers to a process of diminishing the richness of uses and the relationships with the ornamental richness of plants and their unique dominance toward a gardening process (Blanckaert et al. 2004). An additional way is related to the mountain by women in cold and dry contexts and in the decrease of spaces and resources.

Fig. 5 Teresitas and pitayitas in Cuanajo, Michoacan, Mexico. ***(a)*** *Disocactus speciosus* ***(b)*** *Disocactus phyllanthoides* ***(c)*** *Disocactus crenatus x* ***(d)*** *Disocactus x Selenicereus* ***(e)*** *from left to right: Disocacus crenatus x, Disocactus crenatus x, Disocactus x Selenicereus, Disocactus x Epiphyllum, Disocactus x Selenicereus*. (Photos by the authors)

Milpas of the Mountain as Agroforestry Complex

The locality of Transfiguration is in an altitude rage of 2750 to 3200 m in the interior of the Sierra de Monte Alto, a peri-urban zone of Mexico City. Its climate is temperate sub-humid with rains in summer and an average temperature of 16 ° C. Its vegetation is pine-oak forest (*Pinus*, *Abies* and *Quercus*) and riparian forest (García 1998). Around 6000 people inhabit the community and no native language is spoken. The region was formerly occupied by *Hñahñu* people, who have carried out agricultural activities since ancient times. Later, these groups moved to the northeast of the state of México (Esparza 1999). Currently, in addition to agriculture, fishing, harvesting, charcoal production and the provision of services are carried out.

The "milpas" are the predominant systems in the region and their arrangement is based on the integration of wild and cultivated plant and fauna diversity, these characters make them systems under agroforestry management. Its basic composition includes "criollo" maize (*Zea mays*) including black, white and red varieties, fava bean (*Vicia faba*); bean (*Phaseolus vulgaris*) including black, yellow, red, brown and purple pinto varieties; squash (*Cucurbita pepo*) and "chilacayote" (*Cucurbita ficifolia*). Other species of nutritional and cultural value within these systems are the native or wild potato (*Solanum* sp.) and the foreign potato (*Oxalis tuberosa*), which are normally cultivated in the highest and temperate zones of the community. In the agroforestry milpas (AFM) trough semi terrace additionally to the annual and perennial crops represented by fruit trees such as "capulín" (*Prunus serotina*), "pear" (*Pyrus communis*) and "tejocote" (*Crataegus mexicana*) are maintained; as well as other plants such as prickly pear (*Opuntia* spp.) and maguey

Fig. 6 In Transfiguración community, the presence of semi-terraces and agroforestry practices for soil retention was recorded, these house fruit trees such as capulín (*Prunus serotina*) and tejocote (*Crataegus mexicana*), in addition to magueyes (*Agave salmiana*), a species used for the extraction of sap for "pulque" production. (Photo by the authors)

(*Agave salmiana*). In addition, forest or wild species that are under some degree of management such as oak (*Quercus* sp.), pine (*Pinus* spp.), *oyamel* (*Abies religiosa*), *madroño* (*Arbutus xalapensis*), and *aile* (*Alnus acuminata*) (Fig. 6). This agrobiodiversity is included as part of the different agroforestry practices such as isolated trees, boundaries, vegetation patches, and islands of vegetation.

Finally, it is important to mention the fauna composition of the AFM, which is represented by a total of seven species of mammals, one reptile, and 25 species of birds. Some of these species are *cacomixtle* (*Bassariscus astutus*), wild rabbit (*Sylavilagus floridanus*), *cascabel* (*Crotalus* sp.), *jilguero* (*Myadestes occidentalis*), *zopilote* (*Coragyps atratus*), and *pavito* (*Myioborus pictus*).

Agrosilviculturization in Urban Contexts: Community and Collective Gardens in Peri-Urban Mexico City

The Valley of Mexico where Mexico City is located is at an altitude of 2428 m, with an extension of 9600 km^2, surrounded by a volcanic mountain range. The climate is temperate with summer rains, the average temperature is between 18 and 24 °C, the average annual precipitation ranges from 1000 and 1400 mm (Torres et al. 2000). In Mexico City and its metropolitan area, around 21 million people lived in 2017 (ONU HABITAT 2020; Torres et al. 2000). According to the 2015 intercensal survey, of the total of employed people only 0.39% worked in the agricultural sector (INEGI 2020a).

Fig. 7 The oak-pine vegetation that surrounds the collective garden "Los Cedros" is found in the peri-urban context of Mexico City; this is an example of implementation of collective gardens that are affected by the urbanization of rural areas. The trees in the place allow to obtain food, materials, medicines, they serve as windbreaks. Agaves allow to stabilize the terraces that must be used in the context of the slopes of the elevations. (Photo by the authors)

The space and time for agriculture is conceived as limited by the elevation and the population density and the influence of the city in daily life.

The community gardens of Mexico City are characterized by possessing a high diversity of managed species arranged in polycultures and agroforestry models which include native plants, vegetables, medicinal plants, edible and ornamental flowers, fruit trees, among others. Its origin may be related to the inclusion of agriculture and agroforestry in urban and peri-urban contexts or due to the expansion of the city into areas that were previously agricultural (Fig. 7) (Borelli et al. 2017). There are several reasons for the selection of species, among which are temporality, personal taste, commercial demand or for having a specific role in the garden. However, there are also species that were already in the plots before orchards were implemented, this especially occurs with fruit, timber or fuel trees. Yields of this type of garden can be for self-consumption, sale, or used in pedagogical activities. Another important characteristic of community gardens is that they are managed through agroecological practices. Regarding the management of weeds, this can be done through biological control, physical protections or manual weeding. In some cases, material is previously used as a "bed" for domestic animals like fowl, where it mixes with its guano and is later used in the cultivation beds, increasing soil fertility. To control pests and diseases biological management is used, like the cultivation of

ladybugs, physical traps, attracting trap plants, association of crops (Beilin and Hunter 2011).

Fertilization processes are mainly managed by compost and vermicompost methods, where wastes from the garden are processed, as well as tree pruning. Also, specific species are planted that contribute to this end. Finally, there are strategies for efficient use of water, among which are the use of mulch, drip irrigation and directed irrigation (for example, clay pots buried and filled with water). In some cases, there is a presence of fauna that interacts with different processes in the garden, such as chickens and ducks that control pests and weeds, wild birds that spreads seeds, cats and dogs' control urban pests and serve as guardians, as well as insects that promote pollination.

As for the social part of collective gardens, these are managed by groups of people, which can be organized in different ways, for example, being under the coordination of a civil society, extensive family, community, or a government entity. On the other hand, the forms of participation are usually by volunteering or employment. Most of the land does not belong to the people who maintain the gardens, so there is certain insecurity about it. Finally, these spaces usually have objectives beyond production, such as being an educational medium, recovering public spaces or promoting environmental issues.

Subhumid and Semiarid Mountains of Mexico and Agrosilviculture

Tempered-Subhumid Transition and Agroforestry Management

Noxtepec is a town located in the State of Mexico at an altitude range of 1600–2500 m, a small community of about 250 mestizo settlers who manage communally their territory. It is a rural population with social backwardness (INEGI 2020). It has a temperate sub-humid climate with summer rains, average temperature of 19 °C and an average rainfall of 1600 mm. It is a reservoir of climates, traditions and species (Tuirán et al. 2000). Its reddish soils are clayey, mostly of forest vocation (50%), followed by agricultural use (40%). It is found in the floristic province of the Balsas River basin, the main types of vegetation are temperate forests dominated by *Pinus* forest, fir forest, *Quercus* forest, mesophyllous forest, and tropical deciduous forest (INEGI 2020).

Maize (*Zea mays*), squash (*Cucurbita* spp.), and beans (*Phaseolus vulgaris*) are mainly sown in these communal lands. People who still dedicate to the labor do it for self-consumption where they have no opportunity to obtain surpluses. The agricultural activities take place in three management spaces: the mountain/hill, the plot or maizefield and the patio where domesticated and non-domesticated species interact and coexist. The forest area (1900 to 2500 m) is used mainly for grazing animals, far from the village and are managed by both adults and young people who are responsible for their care. In this area agricultural activities cannot be carried out, due to the distance, making it difficult to take care for them, in addition to the fact that soils are shallow and extremely rocky, and only grow some plant species like

Fig. 8 Heterogeneous matrix of the village of Noxtepec, were agroforestry practices like patios, maize fields, orchards, and native vegetation interacts in a visible continuum. (Photo by the authors)

grass, cacti, some herbs and flowering plants. Further away, where there are no more management activities there are pines (*Pinus* spp.), oaks (*Quercus* spp.), *amates* or *saiba* (*Ficus* spp.), and the *huizaches* (*Acacia* spp.). The milpa/plot area is located between 1800 and up to 2500 m, this zone allows the subsistence of the inhabitants where maize, sometimes squash and sometimes beans are planted. These areas may be close to homes, where only community farmers can carry out activities, these areas are in variable altitudes because it may be near the forest area or near the patio in the village. To carry out clearance in forest patches to cultivate, slash and burn is practiced. Besides that, the whole area is destined to the management of domesticated species, the presence of non-domesticated native species, such as pines, oaks, and cacti that are used to delimit the land is remarkable. Between 1600 to 1800 m "patios" are located, next to houses being their composition mainly of fruiting and ornamental plants. This area is managed by the inhabitants of the home but is mostly fostered by women. We can find exotic fruit species such as banana (*Musa* x *paradisiaca*), coffee (*Coffea arabica*), lemons (*Citrus* spp.), peaches (*Prunus persica*); and native like guavas (*Psidium guajava*), papayas (*Carica papaya*), avocado (*Persea americana*), among others; we can also find ornamental species. This area features shallow fertile soils that require constant management (Fig. 8).

Although other existing agroforestry systems where forest species interact with maize at higher altitudes of the village, where slabs stone are abundant and are used to stablish terraces, in Noxtepec, also exists a system that is located at the vicinity of

the river and that allows the use and implementation of riparian species intermingled with exotic crops such as coffee.

Agrosylviculture of Palms: Landscape Traditional Management

One of the most bioculturally important palm species in Mexico is *Brahea dulcis*. This species is mainly found at elevations between 800 and 1600 m, in limestone soils, in deciduous tropical forests, oak forests, and xerophytic scrubland from subhumid to semidesertic climates (Pérez-Valladares et al. 2020; Quero 1994). At its distribution range *B. dulcis* has a wide variety of uses, from which the weaving of diverse objects with fibers obtained from its leaves, is an activity that continues to be basic for the economy of several rural communities in Mexico (Pérez-Valladares et al. 2020), as Santa María Ixcatlán and San Juan Sosola in the region known as Mixteca Alta in the state of Oaxaca.

In this region *B. dulcis* outstands for the high number of managements practices related to it, and for the close relationship humans have established with it since ancient times (Smith 1965). The continuous management on the geographic space, has derived in variable socio-ecosystems where *B. dulcis* is the dominant species, these are known as *palmonares* (palm stands), which are almost always actively associated with agricultural production and livestock grazing. *Palmonares* are also source of a diversity of non-timber forest resources, as in Santa María Ixcatlán where 104 of the 115 species recorded in these systems have at least one use, some of them considered basic for subsistence, such as palm, "quelites" (edible herbs), medicinal plants, forages that keep small livestock (Rangel-Landa et al. 2016). The process of palm stands formation take place in such a gradual and unperceivable way, that in occasions the change may go unnoticed, but with time, it gives rise to a complex agrosilvopastoral matrix (Fig. 9). This conforms a type of landscape domestication (Terrell et al. 2003), a process by which people transforms their natural spaces to derive specific resources from their surroundings (Laland et al. 2000; Odling-Smee et al. 1996).

In natural places where the palm distributes, when a plot of native vegetation (for instance, in oak forest or xerophytic shrubland) is cleared for cultivation, individuals of *B. dulcis* are tolerated inside the plot or as part of the boundaries (Fig. 10a) (Blancas 2001; Illsley et al. 2001; Rangel-Landa et al. 2014, 2016; Vallejo et al. 2014). Agricultural practices as soil enrichment, shrubs removal, and fire dedicated to the milpa, enhance the palm; but there are also particular practices explicitly performed for the palms, such as tolerance, pruning dry leaves, and cutting of shoots. The grazing of minor livestock (sheep and goats mostly), as management practice is relevant to maintain *palmonares* since *B. dulcis* is more resistant to grazing effects compared to other species of bushes and trees (Fig. 10b); this favors its dominance. Two types of palm stands are recognized (Fig. 10c), those known as *manchoneras*, where constant young leaves extraction derives in small height plants with colonial individuals; and the *soyacahuiteras,* where less intensive leave harvest, allows the development of arborescent habit and the prevalence of sexual reproduction.

There is also an important temporal dimension context of these interactions. Since this area has been occupied by human cultures over millennia. Throughout time, the

Fig. 9 Mosaic complex of agricultural land use, parcels in fallow and palm groves. *Brahea dulcis* is managed together with other species with high cultural value such as *Juniperus flaccida* (used as living fence, firewood, shadow, forage, medicine and construction) and *Agave salmiana* subsp. *tehuacanensis* (used as living fence, soil control, make the traditional food *barbacoa*, construction). Santa María Ixcatlán, Oaxaca. (Photo by the authors)

same plots that were once natural vegetation under communitarian management, later transformed to agricultural areas by familiar unities; with time left on fallow, the palm can easily proliferate, enhancing the formation of palm stands that are managed by the communities, which in a future could be reconverted to agriculture again. In this way, management of *palmonares* is articulated as a peculiar geographic expression at landscape level, in which management decisions also change through the time. Since agroforestry and management are inter-scalar processes, local actions exercised continually on individuals on places, over time have the faculty of modify large areas through the promotion of plant communities.

This particular way of landscape management, the geographic locations commonly designated for these activities and the historical perspective of land use, project the *palmonares*, as systems that still have a lot to tell. They are related to other forms of human adaptation of natural spaces that modify large areas through the promotion of plant communities. At landscape level, these spaces can be seen as a mosaic of cultural and natural land units intermingled among them. This is accomplished without the profound disruptive outcomes of other kinds of land use and land use change like monocultures. Nevertheless, palm stands shows a decrease in biological diversity in comparison with natural communities, as was documented in Santa María Ixcatlán (Rangel-Landa et al. 2014; Vallejo et al. 2014) and some topics still need further study, such as: effects on soil and hydric dynamics. These are

Fig. 10 Phases and components of the agrosilvopastoral complex of the palmonares. (**a**) Recently opened land for agriculture in Santa María Ixcatlán. Oaks and palms are tolerated inside the cultivation area; (**b**) Grazing goat cattle in a palmonar in Santa María Ixcatlán. (Photo by the authors)

priority issues due to commonly observed erosion processes in these systems (Fig. 10d) that directly affect agricultural production and water supply for human activities.

Interactionships Between Habitants and Diversity in Semiarid Agroforestry Complexes

Within the Tehuacán-Cuicatlán Biosphere Reserve, in the state of Puebla, the town of Zapotitlán Salinas, is located at an altitude range of 1380–1700 m, where soils with high salt content dominate (Dávila et al. 1993). It has a dry, semi-warm climate, with a rainy season in summer, with an average rainfall of 425 mm and an average temperature of 21.2 °C (Dávila et al. 1990). In these adverse conditions, people have developed multiple activities to support their economy.

This locality is inhabited by a mestizo population, descendants of the Popoloca or "Injiva" indigenous culture. The inhabitants are mainly engaged in agriculture, gathering agroforestry diversity, goat breeding, mining and elaboration of onyx handicrafts, salt extraction, and offering tourist services. According to Rzedowski (1978), the vegetation types of this area are thorn forest, grassland and xerophytic scrub. The main plant communities present are the mezquital dominated by *Prosopis laevigata*, the thorn scrub, the tetechera dominated by *Nebuxbaumia tetetzo*, the cardonal dominated by *Chepalocereus coluna-trajani*, the izotal of *Beaucarnea gracilis*, and the tropical deciduous forest (Valiente-Banuet et al. 2000). Within the forms of management of the agro-diversity of Zapotitlán Salinas, agroforestry systems of semi-terraces are in plains with an average altitude of 1546 m. These semi-terraces, also known as "cuaxustles," are agroforestry systems where maize beans and squash are traditionally cultivated (Fig. 11).

Its structure is composed by trees, columnar cacti, globose cacti and shrubs, distributed as isolated individuals, islands or strips of vegetation within the cultivation land, as well as live fences (Moreno-Calles and Casas 2010). Species such as *mezquite* (*Prosopis laevigata*), *manteco* (*Parkinsonia praecox*), *sotolín* (*Beaucarnea gracilis*), *garambullo* (*Myrtillocactus geometrizans*), *tetecho* (*Neobuxbaumia tetetzo*), *pitahaya* (*Selenicereus undatus*), *xoconostle* (*Stenocereus stellatus*), *izote* (*Yucca periculosa*), *pitzometl* (*Agave marmorata*), *prickly pear cactus* (*Opuntia* spp.), and some globose cacti (*Ferocactus latispinus* and *Echinocactus platyacanthus*) (Paredes-Flores et al. 2007).

Derived from a sampling of bird richness within these agroforestry systems, 89 bird species were recorded; 59 species are resident and 30 are migratory. This represents 68% of the documented bird richness for the Zapotitlán Salinas Valley. The families Parulidae (13 species), Tyrannidae (12 species), and the families Trochilidae, Troglodytidae and Passerellidae with seven species were the most abundant. 21 species (23.6%) show some degree of endemism and four species are under some protection category in the Official Mexican Norm (CONABIO 2020); three under special protection (*Parabuteo unicinctus, Falco peregrinus, Aimophila notosticta*) and one threatened (*Geothlypis tolmiei*).

The agroforestry practices present in the semi-terraces of Zapotitlán Salinas, may be providing the birds with foraging and nesting sites, as well as facilitating their movement on a local and landscape scale, due to their proximity to the cacti forest patches and hills.

Fig. 11 Both images illustrate that the plots of these agroforestry systems are surrounded by the forest of columnar cacti and maintain interactions with the "forest," sharing some plant species and maintaining a great associated diversity. (Photo by the authors)

Metepantles: Agroforestry Terraces and Semiterrace of a Template-Semiarid Zone of Tlaxcala, Mexico

The municipality of El Carmen Tequexquitla is located east of the state of Tlaxcala at an altitude range between 2400 to 2700 m. It has a temperate semi-dry climate with summer rains, a dominant vegetation of xerophilous scrub, ecosystem where succulent prickly and rosetophylous plants dominate; there are also coniferous scrub (*Juniperus* spp.), rosetophylous scrub (*Yucca* spp.), sandy desert (dunes), and pine forest, essentially "stone pine" (*Pinus cembroides*) (Muñoz et al. 2006). El Carmen and neighboring municipalities are post-Columbian settlements and that responded to a strategic geographical location, since these places are called "transit sites" and have historically represented highly important trade routes between the center and east of the country, especially toward the Veracruz port. To a lesser extent, some people still make handicrafts made of "ocoxal" or "paja" (dried *Pinus* leaves), tule (*Typha* sp.), and sotol (*Nolina* sp.) basketry (Enciclopedia de los Municipios y Delegaciones de México 2020).

The characteristic agroforestry systems of the region correspond to agroforestry terraces, their arrangement include the incorporation of wild or forest elements, especially plants, as strategies to retain soil, collect water, and reduce the effect of droughts on the main crops. Especially in the state of Tlaxcala, these terraces are known as "metepantles" and one of the main elements that make them up is the maguey (*Agave salmiana*), which gives its name to the system (Fig. 12).

Metepantles have an area between half and one hectare, where two or three rows of vegetation, called *bordos* or terraces, are distributed generally at contour lines, in

Fig. 12 The main arrangement of the El Carmen agroforestry terraces, these strategies are of great importance in maintaining agrobiodiversity since they protect many wild and domesticated plant species, in addition to serving as retainers of water and soil. (Photo by the authors)

which wild and cultivated plants can be found, mainly *magueyes, izotes, sotol* (*Dasylirio*n spp.), cocoons, walnut trees (*Juglans regia*), peaches, and plums (*Prunus* spp.). The main crops associated with this system are maize, beans, and squash, as well as oats and wheat.

Concluding Remarks

- There is an important coincidence between the distribution of the Mexican mountains and the agroforestry complexes.
- This relationship is old, in those with less time it is around one hundred years at least in various places.
- Agroforestry complexes exist in temperate, subhumid and semi-arid mountains. The environmental conditions of the mountains promote diversification strategies that are addressed through agroforestry complexes.
- Social organization is essential in the conditions of low humidity, cold, reduced space, steep slopes, and saline soils, among others, however the surrounding forest diversity is implemented and used, as well as introduced diversity.
- Agroforestry means different paths of relating with the mountains these variety of agroforestry complexes allows people to continue inhabiting them and that favor unique processes such as the domestication of cultivars, species, systems and landscapes ornamentality, edibles, rituality, and social organization that only occurs at these altitude environments.

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Appendix 1 (IPNI)

Family	Specie	Common name	Use	SAF
Acanthaceae	*Justicia spicigera* Schltdl.	Mucle/Muicle	Medicine	Homegardens
Alstroemeriaceae	*Alstroemeria* sp.	Astromelia; Peruvian Lily	Ornamental	Homegardens
Amaranthaceae	*Amaranthus hybridus* L.	Quelite quintonil	Edible	Agroforestry milpas and agroforestry terraces of arid zones
	Beta vulgaris subsp. *cicla* (L.) Schübl. & G. Martens	Chard	Edible	Homegardens

(continued)

Family	Specie	Common name	Use	SAF
Amaryllidaceae	*Allium sativum* L.	Garlic	Edible	Homegardens
	Hippeastrum sp.	Azucena; Lily	Ornamental	Homegardens
	Allium cepa L.	Onion	Food, pest control	Homegardens
Anacardiaceae	*Mangifera indica* L.	Mango	Edible	Homegardens
Annonaceae	*Annona cherimola* Mill.	Cherimoya	Edible	Long fallow systems
Apiaceae	*Pimpinella anisum* L.	Anise	Medicine	Homegardens
	Eryngium carlinae F. Delaroche	Toad Herb	Medicine	Long fallow systems
	Foeniculum vulgare Mill.	Fennel	Medicine	Homegardens
Arecaceae	*Brahea dulcis* (Kunth) Mart.	Soyate; Creole palm	Edible, handcrafted, ceremonial and construction	Agroforestry terraces of arid zones
Asparagaceae	*Agave marmorata* Roezl	Maguey pitzometl	Beverage and medicine	Agroforestry terraces of arid zones
	Yucca periculosa Baker	Izote	Fiber	Agroforestry terraces of arid zones
	Yucca sp.	Izotes	Edible (flowers)	Agroforestry terraces of arid zones
	Agave salmiana Otto ex. Salm Dyck	Maguey cenizo o manso; Ash-colored or tame maguey	Boundary and edible	Agroforestry milpas and agroforestry terraces of arid zones
	Agave sp.	Maguey	Boundary	Agroforestry milpas and agroforestry terraces of arid zones
	Dasylirion sp.	Sotol	Handcrafted	Agroforestry terraces of arid zones
	Beaucarnea gracilis Lem.	Sotolín	Fodder and ornamental	Agroforestry terraces of arid zones
Asphodelaceae	*Aloe vera* (L.) Burm. f.	Aloe	Medicine	Homegardens
Asteraceae	*Heterotheca inuloides* Cass.	Mexican arnica	Medicine	Homegardens

(continued)

Family	Specie	Common name	Use	SAF
	Baccharis conferta Kunth	Chamizo	Timber and firewood	Agroforestry milpas and Long fallow systems
	Dahlia coccinea Cav.	Dalia	Ornamental	Homegardens
	Gazania sp.	Sleepy plant	Ornamental	Homegardens
	Lactuca sativa L.	Lettuce	Edible	Homegardens
	Artemisia ludoviciana Nutt.	Prodigiosa, estafiate	Medicine	Homegardens
	Senecio rowleyanus H.Jacobsen	Rosary	Ornamental	Homegardens
Basidiomycota	*Ustilago maydis* (DC) Corda	Huitlacoche	Edible	Agroforestry milpas
Begoniaceae	*Begonia* sp.	Angel wing	Ornamental	Homegardens
	Begonia spp.	Begoña	Ornamental	Homegardens
Betulaceae	*Alnus* sp.	Aile	Boundary and windbreakers	Agroforestry milpas
	Alnus acuminata Kunth	Eagle stick	Timber and firewood	Long fallow systems
Brassicaceae	*Raphanus sativus* L.	Radish	Edible	Homegardens
Burseraceae	*Bursera* sp.	Copal		Long fallow systems
Cactaceae	*Echinocactus platyacanthus* Link & Otto	Biznaga	Ornamental	Agroforestry terraces of arid zones
	Ferocactus latispinus (Haw.) Britton & Rose	Biznaga with hooked spines	Ornamental	Agroforestry terraces of arid zones
	Disocactus flagelliformis (L.) Lem.	Floricuerno	Ornamental	Homegardens
	Myrtillocactus geometrizans (Mart. ex Pfeiff.) Console	Garambullo	Edible	Agroforestry terraces of arid zones
	Opuntia sp.	Nopales	Boundary	Agroforestry milpas and agroforestry terraces of arid zones
	Hylocereus undatus (Haw.) Britton & Rose	Dragon fruit	Edible	Homegardens
	Disocactus spp. (*Disocactus speciosus* (Cav.) Barthlott,	Teresita/ pitaya / palmita	Ornamental	Homegardens

(continued)

Family	Specie	Common name	Use	SAF
	Disocactus phyllanthoides (DC.) Barthlott, *Disocactus* x *Selenicereus*, *Disocactus* x *Epiphyllum)*			
	Neobuxbaumia tetetzo (J.M. Coult.) Backeb.	Tetecho	Edible	Agroforestry terraces of arid zones
	Stenocereus stellatus (Pfeiif.) Riccob.	Xoconostle	Edible	Agroforestry terraces of arid zones
Caricaceae	*Carica papaya* L.	Papaya	Edible	Homegardens
Convolvulaceae	*Ipomoea* sp.	Batatilla	Ornamental	Homegardens
Crassulaceae	*Sedum morganianum* E. Walther	Sheep tail	Ornamental	Homegardens
	Sedum rubrotinctum R.T. Clausen	Child finger	Ornamental	Homegardens
	Sedum dasyphyllum L.	Rococo; Cloud	Ornamental	Homegardens
	Kalanchoe tomentosa Baker	Rabbit ear	Ornamental	Homegardens
	Sempervivum calcareum Jord.	Miss nail	Ornamental	Homegardens
Cucurbitaceae	*Cucurbita pepo* L.	Squash	Edible	Agroforestry milpas and Long fallow systems
	Sechium edule (Jacq.) Sw.	Chayote	Edible	Homegardens
	Cucurbita ficifolia Bouché.	Chilacayota or/and chilacayote	Edible	Agroforestry milpas and Long fallow systems
Cupressaceae	*Juniperus deppeana* Steud.	Sabino	Boundary, windbreakers, shade and firewood	Agroforestry terraces of arid zones
	Juniperus flaccida Schltdl.	Táscate, nebro	Firewood	Agroforestry terraces of arid zones
Ericaceae	*Arbutus xalapensis Kunth*	Madroño; madrone	Boundary and windbreakers	Agroforestry milpas
Euphorbiaceae	*Euphorbia milii* Des Moul.		Ornamental	Homegardens

(continued)

Family	Specie	Common name	Use	SAF
		Corona de Cristo; Crown of christ		
	Euphorbia pulcherrima Willd. ex Klotzsch	Nochebuena	Ornamental	Homegardens
Fabaceae	*Erythrina americana* Mill.	Colorín, pipí	Timber and firewood	Long fallow systems and silvopastoril systems
	Phaseolus vulgaris L.	Frijol; Bean	Edible	Agroforestry milpas
	Leucaena leucocephala (Lam.) de Wit	Guaje	Edible	Long fallow system and agroforestry terraces of arid zones
	Vicia faba L.	Haba; Faba bean	Edible	Agroforestry milpas
	Acacia farnesiana(L.) Willd.	Huizache	Fodder	Agroforestry terraces of arid zones
	Parkinsonia praecox (Ruiz & Pav.) Hawkins	Manteco; Greasy tree	Shade	Agroforestry terraces of arid zones
	Prosopis laevigata M. C. Jhonst	Mezquite; Mesquite	Edible, fodder and shade	Agroforestry terraces of arid zones
Fagaceae	*Quercus* sp.	Encino; Oak	Boundary, shade, attractor of rain,, against frost, timber and firewood	Agroforestry milpas and Long fallow systems
Geraniaceae	*Geranium* sp.	Geranio	Ornamental	Homegardens
Hydrangeaceae	*Hydrangea acuminata* Siebold & Zucc.	Hortensia	Ornamental	Homegardens
Juglandaceae	*Juglans regia* L.	Nogal, nuez; Walnut	Edible	Agroforestry milpas
Lamiaceae	*Mentha spicata* L.	Hierbabuena; Peppermint	Medicine	Homegardens
	Lavandula angustifolia Mill.	Lavanda; Lavender	Edible and pollination	Homegardens
	Origanum majorana L.	Mejorana; Marjoram	Medicine	Homegardens
	Mentha piperita L.	Menta; Mint	Edible and medicine	Homegardens
		Mirto	Medicine	Homegardens

(continued)

Family	Specie	Common name	Use	SAF
	Salvia microphylla Kunth			
	Rosmarinus officinalis L.	Romero; Rosemary	Medicine	Homegardens
	Thymus acicularis Waldst. & Kit.	Tomillo; Thyme	Medicine	Homegardens
	Plectranthus coleoides Benth.	Vaporup	Medicine	Homegardens
Lauraceae	*Persea americana* Mill.	Aguacate; Avocado	Edible	Homegardens, Long fallow systems
Lythraceae	*Cuphea ignea* A. DC.	Cigarro de cantinflas	Ornamental	Homegardens
Malvaceae	*Malva* sp.	Malva	Ornamental	Homegardens
Moraceae	*Ficus carica* L.	Higo; Fig	Edible	Homegardens
	Ficus petiolaris Kunth	Saiba Amarilla	Shade and boundary	Long fallow systems
Musaceae	*Musa* × *paradisiaca* L.	Plátano; Banana	Edible	Homegardens
Myrtaceae	*Psidium guajava* L.	Guayaba; Guava	Edible	Long fallow systems
Nyctaginaceae	*Bougainvillea glabra* Choisy	Bugambilia	Ornamental	Homegardens
Oleaceae	*Fraxinus* sp.	Fresnos	Timber and firewood	Long fallow systems
Onagraceae	*Fuchsia* sp.	Arete/ fucsia; Earring	Ornamental	Homegardens
Orchidaceae	*Epidendrum radicans* Pav. ex Lindl.	Espíritu Santo; Holy Spirit	Ornamental	Homegardens
Oxalidaceae	*Oxalis tuberosa* Molina	Papa extranjera; Foreign potato	Edible	Agroforestry milpas
Pinaceae	*Pinus lawsonii* Roezl ex Gordon	Ocote	Timber and firewood	Long fallow systems
	Abies religiosa (Kunth) Schltdl. & Cham	Oyamel	Boundary, firewood and recreational	Agroforestry milpas
	Pinus cembroides Zucc.	Pino piñonero; Pinyon Pine	Edible (seeds)	Agroforestry terraces of arid zones
	Pinus sp.	Pino: Pine	Timber, firewoood and boundary	Agroforestry milpas and Long fallow systems
Poaceae	*Zea mays* L.		Edible	

(continued)

Family	Specie	Common name	Use	SAF
		Maíz; maize, corn		Agroforestry milpas
	Cymbopogon citratus (D.C.) Stapf	Té Limón: Lemon tea	Medicine	Homegardens
Rosaceae	*Prunus serotina* subsp. *capuli* (Cav.) McVaugh	Capulines; Black cherry	Food, boundary	Agroforestry milpas and Long fallow systems
	Prunus armeniaca L.	Chabacano; Apricot	Edible	Homegardens ans agroforestry milpas
	Prunus domestica L.	Ciruelos; Plum	Edible	Homegardens ans agroforestry milpas
	Prunus persica L.	Duraznos; Peach	Food and windbreakers	Agroforestry milpas and Long fallow systems
	Fragaria sp.	Fresa; Strawberry	Edible	Homegardens
	Malus domestica (Suckow) Borkh.	Manzano; Apple	Edible and shade	Homegardens ans agroforestry milpas
	Cydonia oblonga Mill.	Membrillo; Quince	Edible	Homegardens
	Eriobotrya japonica (Thunb.) Lindl.	Níspero; Japanese medlar	Edible	Homegardens
	Pyrus communis L.	Pera; Pear	Boundary, edible and windbreakers	Homegardens ans agroforestry milpas
	Crataegus mexicana DC.	Tejocote; Mexican hawthorn	Boundary, winbreaks and edible	Homegardens ans agroforestry milpas
Rubiaceae	*Coffea arabica* L.	Café; Coffee	Edible	Homegardens
Rutaceae	*Citrus x limon* (L.) Obsbeck	Limón; Lemon	Edible and shade	Homegardens
	Citrus sinesis (L.) Osbeck	Naranja; Orange	Edible	Homegardens
	Ruta graveolens L.	Ruda	Medicine	Homegardens
Solanaceae	*Capsicum annuum* L.	Chile; Chili pepper	Food and pest control	Homegardens
			Edible	Homegardens

(continued)

Family	Specie	Common name	Use	SAF
	Capsicum pubescens Ruiz & Pav.	Chile perón, canario		
	Physalis philadelphica Lam	Miltomate	Edible	Agroforestry milpas and agroforestry terraces of arid zones
	Solanum lycopersicum L.	Jitomate; Tomato	Edible	Homegardens
	Solanum sp.	Papa criolla; Creole potato	Edible	Agroforestry milpas

Appendix 2

Common name	Specie	Use	SAF
Bassarisk	*Bassariscus astutus*		Agroforestry milpas
Mountain rabbit	*Sylavilagus floridanus*	Food	Agroforestry milpas
Snake	*Crotalus* sp.		Agroforestry milpas
Brown-backed solitaire	*Myadestes occidentalis*		Agroforestry milpas
Black vulture	*Coragyps atratus*		Agroforestry milpas
Painted redstart	*Myioborus pictus*		Agroforestry milpas

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