

# Participatory diagnosis for the management of degraded forest areas in the Sierra de Guadalupe State Park

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## Research Article

**Keywords:** social-actors, sociecosystem, arboreal-native, *Prosopis laevigata*, restoration, conservation

**Posted Date:** October 28th, 2023

**DOI:** <https://doi.org/10.21203/rs.3.rs-3482700/v1>

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**Additional Declarations:** No competing interests reported.

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# Abstract

Participatory diagnosis is the methodological process through which society participates in order to undertake and achieve sustainable development with the contribution of science and collective knowledge. The objective of this research is to analyze the current situation of the Sierra de Guadalupe State Park (SGSP) from the natural, historical, economic, and social aspects, through participatory research and thus influence the selection of trees and shrubs of multiple uses for reforestation that have the potential to establish agroforestry and silvopastoral systems. This study was carried out with the help of the following tools that are commonly used in a participatory diagnosis: SWOT analysis, timeline, and identification and classification of natural resources. In order to determine the current problems of the state park (SGSP), the "problem tree" method was used. To identify possible solutions to this problem, a collaborative workshop was conducted in which negative conditions were assigned to positive actions. In addition, 141 semi-structured interviews were conducted with relevant actors in the society using the "snowball" methodology. Field visits were also conducted to complement the information. A total of 72 and 44 species of wild fauna and flora, respectively. The priority forest species considered to initiate the restoration actions were: *Prosopis laevigata*, *Vachellia schaffneri*, and *Quercus rugosa*. The shrub species were: *Opuntia tomentosa*, *Opuntia hyptiacatha*, and *Agave salmiana*. In conclusion, with this study, reliable technical knowledge was generated with the participation of society, which will be used to carry out actions of protection, restoration, conservation, and productive reconversion.

## Introduction

Often, agricultural and forestry problems are identified from a disciplinary and interpretative perspective of a reality that does not represent the opinion of the involved actors, generating incomplete and biased diagnoses (Bautista-Zúñiga et al. 2005). For the success of exogenous actions (intervention, organization, and research) aimed at the development of a socioecosystem, it is convenient to promote the participation of the social actors involved. Participatory research considers the generation of knowledge by articulating the contribution of science and popular knowledge (Durstun and Miranda 2002). This approach is used to develop alternative productive projects that reconcile the use of natural resources and their conservation (Martínez et al. 1996; Bocco et al. 2000; Negrete and Bocco 2003). Participatory action refers to those concepts that establish the relationships between human beings, society, and nature, as well as aspects of equity, self-management, sustainability, democratization, and governance, among others (Van Dam 2000).

Participatory diagnosis is the methodological process that privileges the conscious participation of a community that manages transformative actions to achieve sustainable development (Muñíos 2006; Véliz 2014). This methodology facilitates the identification of strengths, weaknesses, and areas of opportunity to generate proposals and intervention strategies in a given territory (Luján-Álvarez et al. 2021), as well as to learn about the past, explain the current situation and predict future trends (Domínguez and López-Collado 1996). Methodologically, diagnosis is the first step in the elaboration of land use planning, followed by the forecast and proposal phases (CONAFOR 2007); it has also been used in decision-making and construction of management programs (Martínez et al. 1996; Ortiz et al. 2017; Sandoval-Díaz and Martínez-Labrín 2021). The objective of the present research is to analyze the current situation of the Sierra de Guadalupe State Park from the aspects: natural, historical, economic, and social, through Participatory Research to influence the selection of trees and shrubs of multiple uses for reforestation that have the potential to establish agroforestry and silvopastoral systems.

## Materials and methods

Sierra de Guadalupe State Park (SGSP) is a Natural Protected Area located in the hydrological region of the Upper Pánuco River, in the Moctezuma River Basin, north of Mexico City (Fig. 1). This territory is distributed among the municipalities of Coacalco (24%), Ecatepec (34%), Tlalnepantla (21%), and Tultitlán (21%), in the State of Mexico (Ipomex 2015). The climate is temperate sub-humid C(w)(w)(w)(i)g, with summer rainfall, winter precipitation less than 5% of the annual average, average annual rainfall between 699 and 800 mm, and average annual temperature between 12 and 16°C (García 2004). The territorial area is approximately 5293 hectares; it is distributed in an altitudinal range of 2730 to 3055 m.a.s.l. Land use and vegetation are mainly pasture (29%), eucalyptus reforestation (14%), scrub (12%) and thorny scrub (11.5%), oak forest (9.9%), cactus (9.8%), and agricultural crops (6.7%), among others (Secretaría de Ecología 1999). Land tenure is ejido, communal property, private property, federal, state, and municipal (Pronatura 2021).

The methodological scheme was constructed through participatory didactic tools (Fig. 2). In the first stage of the participatory research, documental information was collected, organized, systematized, and analyzed from databases, cartography, reports, and research articles; in the second stage, field trips were conducted in transects, with the integration of a multidisciplinary work team, implementing the technique of participant observation (Piñeiro 2015); also, a workshop was developed with the presence of the social actors that are present in the study area. As a result of the participatory workshop, a SWOT analysis and timeline were constructed based on Geilfus (2009); the natural resources present (wildlife) were identified, prioritizing trees and shrubs of multiple uses for reforestation and with potential for the establishment of agroforestry and silvopastoral systems. For the analysis, native and endemic species were considered, discarding introduced species. For this purpose, fauna and flora species were identified by their scientific name and taxonomically classified. In the case of wildlife, it was indicated geographic distribution and international and local conservation status. Permitted and restricted activities were recorded and analyzed by a number of mentions using the "word cloud" tool available in WordItOut, in which the frequencies of words are represented visually, the higher the frequency, the larger the size and representation of the cloud to capture attention at first glance.

*Identification and classification of the problem.* Based on Cohen and Martínez (2008), the "problem tree" and the "objectives tree" were constructed. In the problem tree diagram, the main problem was identified at the trunk, the causes at the roots, and the effects at the top. In the objectives tree, the future situation was represented in a scenario where the problem could be solved. In addition, semi-structured interviews were conducted with social actors using the "snowball" method (Reed et al. 2009). The interview format made it possible to identify the type of actor to be interviewed; for this purpose, their occupation was considered in order to know their economic and social role.

The trees and shrubs of multiple uses were listed. Also recorded were those that are no longer found and that in the past were abundant, as well as the management and conservation activities carried out by the community, identifying the main problems. The results workshop consisted of presenting the preliminary results of the participatory workshop to promote feedback. In addition, the activity of "development of triggering projects" was carried out according to the methodological guide proposed by SEMARNAT and CONANP (2017).

## Results and discussion

*SWOT analysis.* The SWOT analysis was carried out to identify and analyze the main strengths, weaknesses, opportunities, and threats in the SGSP (Fig. 3). This tool was used to organize and order the ideas in a didactic and understandable approach. There were two ways of presentation, on the one hand, the positive aspects and, on the other, the negative aspects. Within both, a distinction is made between those of an internal nature (strengths and weaknesses) and those with external connotations (opportunities and threats).

*Timeline.* The Sierra de Guadalupe (SG) has had three stages in the use of natural resources. Periods: pre-Hispanic, colonial, and modern (Table 1). In pre-Hispanic times, the inhabitants settled in the north of the Valley of Mexico, near Lake Texcoco, on arable land and next to the forest. During this period, the cultivation of corn, beans, and squash allowed the establishment of sedentary villages (Cyphers 1981). In colonial times, the territory of New Spain shifted from an agriculture-based economy to the extraction of precious metals (gold and silver) for export and the formation of large agricultural and cattle ranches (Commons 1983). During the modern era, the SG became a receiving area for population through invasion, irregular settlements, and urbanization (GEM et al. 2002). Irregular settlements advanced along the periphery and foothills. This growth accelerated in the 1990s, covering the entire foothills and part of the hillsides (Lugo-Hubp and Salinas-Montes 1996).

Table 1  
Timeline of Sierra de Guadalupe State Park, Mexico

| Pre-Hispanic period                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Colonial period                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Modern period (1900–1979)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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| <p>The north of the Valley of Mexico (VM) was populated since pre-Hispanic times (GEM et al. 2002). The indigenous Tepanec Indians dominated the SG region (Navarrete 2019); these inhabitants settled near Lake Texcoco on arable land and next to the forest. The cultivation of maize, beans, and squash allowed the establishment of sedentary villages (Cyphers 1981).</p> <p><b>900 – 400 B.C.</b> Preclassic villages at El Arbolillo and Zacatenco, basic foundations for the evolution of civilization and urbanization in Mesoamerica (Cyphers 1981).</p> <p><b>1500 B.C. – 1204 A.D.</b> Arrival of Mexica to Ecatepec, they stayed 40 years.</p> <p><b>1260–1263</b> Aztecs stopped in towns near Ecatepec.</p> <p><b>1220</b> Otomi settlement in Xaltocan.</p> <p><b>1519</b> Spanish arrived on the shores of the Gulf of Mexico. Mesoamerica dominated by Mexica.</p> | <p><b>1521</b> the Spanish took over Tenochtitlán after great battles and prolonged sieges (Imaz 1989).</p> <p><b>1526</b> Dominican friars arrived in Ecatepec and began the evangelization of the indigenous people.</p> <p><b>1527</b> was in Veracruz where the first cattle arrived in New Spain, ancestors of the herds (Barrera 1996), introduction of cattle and logging.</p> <p><b>1604–1612</b> great flood of the Capital of New Spain (Imaz 1989), construction of the albaradón of Ecatepec. The Ehecatepetl/Cerro Ehécatl, called: Cerro de la Cruz.</p> <p><b>1620</b> in the center of New Spain grazed around 1300000 cattle, 8100000 sheep, and goats, occupying 77700 km<sup>2</sup> (Barrera 1996).</p> <p><b>1500–1599</b> the Basin of Mexico was one of the most populated and important areas in Mesoamerica (Commons 1983).</p> <p><b>1801</b> growth of cattle ranching and logging, transformation of the natural landscape.</p> <p>Coacalco had oak forests in the highlands, cattle ranching, and the San Francisco temple was already part of the landscape (Olivares 2013).</p> | <p><b>1900</b> sawmill in Tultitlán, overexploitation of oak trees.</p> <p><b>1923</b> decree: Forest Protection Zone.</p> <p><b>1930</b> agricultural distribution, mining (quarries).</p> <p><b>1937</b> declaration of El Tepeyac National Park CDMX, 1500 ha.</p> <p><b>1939–1949</b> discovery of archaeological remains cave with cave paintings in Cerro de la Cruz, ceramics in Cerro Ehécatl, sherds and structures indicate that the southwestern zone was inhabited (Massieu 1949).</p> <p><b>1950</b> drying of lakes Xaltocan and Texcoco, accelerated urban growth north of the MV (SEDEMA 2016).</p> <p><b>1960–1970</b> William Sanders conducted archaeological research on WV Basin settlements. Urban expansion on hillsides.</p> <p><b>1976</b> decree: State Park (6322 ha.)</p> <p><b>1978</b>, 1,000 hectares are added. Creation of the State Commission of Natural Parks and Fauna (CEPANAF).</p> |

Table 1  
Timeline of Sierra de Guadalupe State Park, Mexico. Continued

| 1980–1999                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 2000–2011                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2012–2019                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2020–2023                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
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| <p><b>1980</b> accelerated population growth, eucalyptus plantations, creation of solid waste disposal sites (Tlalnepantla, Tultitlán and Coacalco).</p> <p><b>1992</b> the SG in the slope of the CDMX is considered a Zone Subject to Ecological Conservation, administered by SEDEMA and CONANP 633.7 ha (11 polygons).</p> <p><b>1993</b> project: ecological conservation of the MCMA, ecological restoration works, security, recreation and surveillance, construction of the Management Plan.</p> <p><b>1996</b> creation of the General Coordination of Ecological Conservation (CGCE) Edo. de Méx.</p> <p><b>1999</b> SGSP Management Program was published (5306 ha), 2,000 less than in 1978. Nine kilometers of the ecological fence were built.</p> | <p><b>2002</b> Agreement between the San Cristobal ejido and the state government, construction of 17 gabion dams. SMA- Edo. Méx. introduces UMAs for exotic ungulates, 3 exhibitors in Tultitlán and one in Coacalco. Construction of 24.5 km of mesh fence (Ipomex 2015).</p> <p><b>2005</b> closure of the garbage dump in Coacalco.</p> <p><b>2008</b> creation of the SG-Coacalco Ecotourism and Environmental Education Center.</p> <p><b>2010</b> environmental monitoring system for the MCMA 5 cameras to detect forest fires, irregular settlements, natural resource extraction, and land use change. Construction of the Ehécatl Ecological Park (EEP).</p> <p><b>2011</b> increase in infrastructure. Volcanological study.</p> | <p><b>2012</b> inauguration of aviary in the PEE, reforestation 46244 trees.</p> <p>5293 hectares were recognized in the SGSP in <b>2013</b>. Closure of the garbage dump in Tultitlán, reforestation of 45220 trees.</p> <p><b>2014</b> construction of SG Integral Environmental Education Center, Tlalnepantla, and last stretch of ecological wall 16 km.</p> <p><b>2015</b> SGSP Management Plan update.</p> <p><b>2016</b> first City Nature Challenge (CNC) Worldwide. Closure of UMAs, creation of Urban Bird Programs (PAU): Ecatepec, Coacalco, Tultitlán, and Tlalnepantla.</p> <p><b>2018</b> agreement Ecatepec, SEMARNAT and CEPANAF rescue and conservation of the ravines: Ehécatl, Las Venitas and Tejocote (Capital Edo. de México 2018).</p> <p><b>2019</b> CNC CDMX.</p> | <p><b>2020</b> SARS pandemic CoV-2. CNC-Cuautitlán Izcalli.</p> <p><b>2021</b> CNC Ecatepec. First SG Festival. Participatory Diagnostic Workshop, Postgraduate in Forestry Sciences - College of Postgraduates (PCF-CP), Autonomous University of Chapingo (UACH).</p> <p>Update of the SGSP Management Plan. Installation of infrastructure for protection and surveillance of the Cerro Ehécatl archeological site. Members of sports and environmental groups request permanent presence of the national guard.</p> <p><b>2022.</b> CNC Ecatepec. demonstrations due to lack of water in San Cristobal, Ecatepec.</p> <p><b>2023.</b> Results Workshop: Participatory Research in the SGSP. PCF-CP and UACH.</p> <p>Inventory of rockfalls and geomorphology (Hernández et al. 2023).</p> <p>CNC-Ecatepec.</p> |

Vertebrates are represented by amphibians, reptiles, birds, and mammals, where birds are the most abundant, with some endemic species. There are 128 vertebrate species and five feral species (*Rattus norvegicus*, *Mus musculus*, *Canis familiaris*, *Felis domesticus* and *Melopsitacus undulatus*) (GEM et al. 2002). Hortelano-Moncada et al. (2021) in a mammal inventory found that the natural protected area with most species-rich within the Sierra de Guadalupe is the SGSP with 20 species, followed by the Zona Sujeta a Conservación Ecológica Sierra de Guadalupe with 17 species, the Zona de Conservación Ecológica La Armella with 8 and the Parque Nacional El Tepeyac with only 7 species. Méndez de la Cruz et al. (1992) reported 24 species of amphibians and reptiles (seven and seventeen, respectively) in the Sierra de Guadalupe, corresponding to 43% of the herpetofauna of the Valley of Mexico. Puga-Caballero et al. (2014) recorded 43 species of resident birds, three exotic species (*Columba livia*, *Sturnus vulgaris*, and *Passer domesticus*), one quasi-demic of Mexico (*Basileuterus rufifrons*), one under special protection by the Mexican government (*Athene cunicularia*; SEMARNAT 2010). This analysis of wildlife diversity in the study area will allow the development of conservation strategies for amphibians, reptiles, birds, and mammals, as proposed by Xu et al. (2008). This inventory is necessary to diversify economic activities and recover the productive capacity of the ecosystem (Bocco et al. 2000).

Table 2  
Participatory list of wildlife in Sierra de Guadalupe State Park, Mexico

| Clase     | Orden            | Familia       | Nombre científico                      | Distribución | NOM-059-SEMARNAT-2010 | IUCN Red List | CITES (2019) |
|-----------|------------------|---------------|----------------------------------------|--------------|-----------------------|---------------|--------------|
| Amphibia  | Anura            | Hylidae       | <i>Hyla arenicolor</i>                 | R            | SC                    | LC            | SC           |
| Amphibia  | Anura            | Hylidae       | <i>Hyla eximia</i>                     | E            | SC                    | LC            | SC           |
| Arachnida | Araneae          | Sicariidae    | <i>Loxosceles misteca</i>              | R            | SC                    | SC            | SC           |
| Arachnida | Araneae          | Theridiidae   | <i>Latrodectus mactans</i>             | R            | SC                    | SC            | SC           |
| Arachnida | Araneae          | Theraphosidae | <i>Bonnetina aviae</i>                 | E            | SC                    | SC            | SC           |
| Arachnida | Scorpiones       | Vaejovidae    | <i>Vaejovis mexicanus</i>              | R            | SC                    | SC            | SC           |
| Aves      | Accipitriformes  | Accipitridae  | <i>Buteo jamaicensis</i>               | R            | SC                    | LC            | SC           |
| Aves      | Accipitriformes  | Accipitridae  | <i>Parabuteo unicinctus</i>            | R            | Pr                    | LC            | SC           |
| Aves      | Apodiformes      | Trochilidae   | <i>Cynanthus latirostris</i>           | R            | SC                    | LC            | All          |
| Aves      | Apodiformes      | Trochilidae   | <i>Amazilia violiceps</i>              | R            | SC                    | LC            | All          |
| Aves      | Apodiformes      | Trochilidae   | <i>Amazilia beryllina</i>              | R            | SC                    | LC            | All          |
| Aves      | Apodiformes      | Trochilidae   | <i>Calothorax lucifer</i>              | RNR          | SC                    | LC            | All          |
| Aves      | Apodiformes      | Trochilidae   | <i>Hylocharis leucotis</i>             | R            | SC                    | LC            | All          |
| Aves      | Apodiformes      | Trochilidae   | <i>Selasphorus calliope</i>            | R            | SC                    | LC            | All          |
| Aves      | Apodiformes      | Trochilidae   | <i>Eugenes fulgens</i>                 | R            | SC                    | LC            | All          |
| Aves      | Caprimulgiformes | Caprimulgidae | <i>Antrostomus arizonae</i>            | R            | SC                    | LC            | SC           |
| Aves      | Cuculiformes     | Cuculidae     | <i>Geococcyx californianus</i>         | R            | SC                    | LC            | SC           |
| Aves      | Falconiformes    | Falconidae    | <i>Falco sparverius</i>                | EP           | SC                    | LC            | All          |
| Aves      | Passeriformes    | Mimidae       | <i>Toxostoma curvirostre</i>           | R            | SC                    | LC            | SC           |
| Aves      | Passeriformes    | Troglodytidae | <i>Campylorhynchus brunneicapillus</i> | NN           | SC                    | LC            | SC           |
| Aves      | Passeriformes    | Icteridae     | <i>Quiscalus mexicanus</i>             | R            | SC                    | LC            | SC           |
| Aves      | Passeriformes    | Fringillidae  | <i>Haemorhous mexicanus</i>            | R            | SC                    | LC            | SC           |
| Aves      | Passeriformes    | Mimidae       | <i>Toxostoma ocellatum</i>             | R            | SC                    | LC            | SC           |
| Aves      | Passeriformes    | Cardinalidae  | <i>Cardinalis cardinalis</i>           | NN           | SC                    | LC            | SC           |
| Aves      | Passeriformes    | Tyrannidae    | <i>Pyrocephalus rubinus</i>            | R            | SC                    | LC            | SC           |

| Clase        | Orden          | Familia       | Nombre científico                | Distribución | NOM-059-SEMARNAT-2010 | IUCN Red List | CITES (2019) |
|--------------|----------------|---------------|----------------------------------|--------------|-----------------------|---------------|--------------|
| Aves         | Passeriformes  | Mimidae       | <i>Mimus polyglottos</i>         | R            | SC                    | LC            | SC           |
| Aves         | Passeriformes  | Cardinalidae  | <i>Pheucticus melanocephalus</i> | R            | SC                    | LC            | SC           |
| Aves         | Passeriformes  | Troglodytidae | <i>Thryomanes bewickii</i>       | EP           | SC                    | LC            | SC           |
| Aves         | Passeriformes  | Icteridae     | <i>Icterus wagleri</i>           | R            | SC                    | LC            | SC           |
| Aves         | Passeriformes  | Tyrannidae    | <i>Epidonax sp.</i>              | R            | SC                    | SC            | SC           |
| Aves         | Passeriformes  | Tyrannidae    | <i>Contopus sp.</i>              | R            | SC                    | SC            | SC           |
| Aves         | Passeriformes  | Tyrannidae    | <i>Sayornis sp.</i>              | R            | SC                    | SC            | SC           |
| Aves         | Piciformes     | Picidae       | <i>Dryobates scalaris</i>        | R            | SC                    | LC            | SC           |
| Aves         | Piciformes     | Picidae       | <i>Melanerpes aurifrons</i>      | NN           | SC                    | LC            | SC           |
| Aves         | Psittaciformes | Psittacidae   | <i>Myiopsitta monachus</i>       | NN           | SC                    | LC            | SC           |
| Aves         | Strigiformes   | Tytonidae     | <i>Tyto alba</i>                 | R            | SC                    | LC            | All          |
| Aves         | Strigiformes   | Strigidae     | <i>Bubo virginianus</i>          | R            | SC                    | LC            | All          |
| Insecta      | Coleoptera     | Phanaeus      | <i>Phanaeus mexicanus</i>        | R            | SC                    | SC            | SC           |
| Insecta      | Coleoptera     | Scarabaeidae  | <i>Canthon sp.</i>               | R            | SC                    | SC            | SC           |
| Insecta      | Odonata        | Libellulidae  | <i>Sympetrum illotum</i>         | NN           | SC                    | LC            | SC           |
| Insecta      | Coleoptera     | Scarabaeidae  | <i>Cotinis mutabilis</i>         | R            | SC                    | SC            | SC           |
| Insecta      | Coleoptera     | Cerambycidae  | <i>Cerambycidae sp.</i>          | R            | SC                    | SC            | SC           |
| Insecta      | Coleoptera     | Lampyridae    | <i>Photinus extensus</i>         | R            | SC                    | SC            | SC           |
| Insecta      | Hemiptera      | Thasus        | <i>Thasus gigas</i>              | R            | SC                    | SC            | SC           |
| Insecta      | Hymenoptera    | Apidae        | <i>Apis mellifera</i>            | NN           | SC                    | SC            | SC           |
| Insecta      | Lepidoptera    | Danaidae      | <i>Danaus plexippus</i>          | RNR          | Pr                    | LC            | SC           |
| Insecta      | Lepidoptera    | Nymphalidae   | <i>Dione moneta</i>              | R            | SC                    | SC            | SC           |
| Insecta      | Mantodea       | Mantidae      | <i>Phyllovates clorophaea</i>    | R            | SC                    | SC            | SC           |
| Malacostraca | Decapoda       | Cambaridae    | <i>Cambarellus montezumae</i>    | R            | SC                    | LC            | SC           |
| Mammalia     | Carnivora      | Canidae       | <i>Urocyon cinereoargenteus</i>  | R            | SC                    | LC            | SC           |
| Mammalia     | Carnivora      | Procyonidae   | <i>Bassariscus astutus</i>       | R            | SC                    | LC            | SC           |
| Mammalia     | Carnivora      | Felidae       | <i>Lynx rufus</i>                | R            | SC                    | LC            | All          |

| Clase    | Orden           | Familia          | Nombre científico                 | Distribución | NOM-059-SEMARNAT-2010 | IUCN Red List | CITES (2019) |
|----------|-----------------|------------------|-----------------------------------|--------------|-----------------------|---------------|--------------|
| Mammalia | Chiroptera      | Phyllostomidae   | <i>Choeronycteris mexicana</i>    | R            | A                     | NT            | SC           |
| Mammalia | Chiroptera      | Vespertilionidae | <i>Lasiurus cinereus</i>          | R            | SC                    | LC            | SC           |
| Mammalia | Didelphimorphia | Didelphidae      | <i>Didelphis virginiana</i>       | R            | SC                    | LC            | SC           |
| Mammalia | Lagomorpha      | Leporidae        | <i>Sylvilagus floridanus</i>      | R            | SC                    | LC            | SC           |
| Mammalia | Rodentia        | Muridae          | <i>Rattus norvegicus</i>          | NN           | SC                    | LC            | SC           |
| Mammalia | Rodentia        | Cricetidae       | <i>Sigmodon leucotis</i>          | E            | SC                    | LC            | SC           |
| Mammalia | Rodentia        | Sciuridae        | <i>Otospermophilus variegatus</i> | R            | SC                    | LC            | SC           |
| Mammalia | Rodentia        | Geomyidae        | <i>Cratogeomys fumosus</i>        | R            | SC                    | LC            | SC           |
| Reptilia | Squamata        | Colubridae       | <i>Thamnophis sp.</i>             | R            | SC                    | SC            | SC           |
| Reptilia | Squamata        | Phrynosomatidae  | <i>Sceloporus torquatus</i>       | E            | SC                    | LC            | SC           |
| Reptilia | Squamata        | Phrynosomatidae  | <i>Phrynosoma sp.</i>             | R            | SC                    | SC            | SC           |
| Reptilia | Squamata        | Anguidae         | <i>Barisia imbricata</i>          | E            | Pr                    | LC            | SC           |
| Reptilia | Squamata        | Phrynosomatidae  | <i>Sceloporus mucronatus</i>      | E            | SC                    | LC            | SC           |
| Reptilia | Squamata        | Phrynosomatidae  | <i>Sceloporus spinosus</i>        | E            | SC                    | LC            | SC           |
| Reptilia | Squamata        | Colubridae       | <i>Salvadora bairdi</i>           | E            | Pr                    | LC            | SC           |
| Reptilia | Squamata        | Colubridae       | <i>Conopsis nasus</i>             | E            | SC                    | LC            | SC           |
| Reptilia | Squamata        | Colubridae       | <i>Conopsis lineata</i>           | E            | SC                    | LC            | SC           |
| Reptilia | Squamata        | Colubridae       | <i>Pituophis deppei</i>           | E            | A                     | LC            | SC           |
| Reptilia | Squamata        | Viperidae        | <i>Crotalus atrox</i>             | NN           | Pr                    | LC            | SC           |
| Mammalia | Carnivora       | Mephitidae       | <i>Spilogale angustifrons</i>     | R            | SC                    | LC            | SC           |

A = threatened, Pr = subject to special protection, E = endemic, R = resident, RR = resident breeding, RNR = resident non-breeding, EP = existing transient, NN = non-native, SC = no category, LC = minor concern, NT = Near Threatened, All = Appendix II.

**Flora.** Of the total number of interviewees, 15% indicated that endemic and native multipurpose trees should be established for reforestation, and 4.6% mentioned the inclusion of fruit trees (tejocote, capulin, apricot, pear, apple, and avocado) in agroforestry systems. The participants suggested 44 plant species from 17 families, mostly represented by Leguminosae, Asparagaceae, and Rosaceae (Table 3), of which 31 tree and shrub species are native, suitable for reforestation and the establishment of agroforestry and silvopastoral systems. The three most mentioned tree species are: *Prosopis laevigata* (Willd.) M.C.Johnst., *Vachellia schaffneri* (S. Watson) Seigler & Binger, and *Quercus rugosa* (Masam.) J.C.Liao, while the three most mentioned shrub species were: *Opuntia tomentosa* Salm-Dyck, *Opuntia hyptiacatha* F.A.C. Weber, and *Agave salmiana* Otto ex Salm-Dyck.

Most of the tree or shrub species mentioned have multiple uses (retention and regeneration of degraded soils, food, fodder, firewood, charcoal, handicrafts, among others), so the ejidatarios involved would be interested in starting reforestation works

prioritizing these species. In silvopastoral systems, these species can be used as shade trees, windbreaks, dispersed trees, live barriers, live fences, etc. (Villanueva 1993).

Table 3  
Multipurpose trees and shrubs mentioned in the survey by users of Sierra de Guadalupe State Park, Mexico

| Distribution | Structure | Family           | Species                                                                       | Percentage of mentions (%) |
|--------------|-----------|------------------|-------------------------------------------------------------------------------|----------------------------|
| Native       | Arborea   | Leguminosae      | <i>Prosopis laevigata</i> (Willd.) M.C.Johnst.                                | 25.5                       |
| Native       | Arborea   | Leguminosae      | <i>Vachellia schaffneri</i> (S. Watson) Seigler & Ebinger                     | 24.1                       |
| Native       | Arborea   | Burseraceae      | <i>Quercus rugosa</i> (Masam.) J.C.Liao                                       | 23.4                       |
| Native       | Arborea   | Fagaceae         | <i>Eysenhardtia polystachya</i> (Ortega) Sarg.                                | 12.1                       |
| Native       | Arborea   | Scrophulariaceae | <i>Bursera cuneata</i> (Schltdl.) Engl.                                       | 8.5                        |
| Native       | Arborea   | Leguminosae      | <i>Crataegus mexicana</i> D.Don                                               | 7.1                        |
| Native       | Arborea   | Cupressaceae     | <i>Yucca filifera</i> Chabaud                                                 | 3.5                        |
| Native       | Arborea   | Bignoniaceae     | <i>Buddleja cordata</i> Kunth                                                 | 2.8                        |
| Native       | Arborea   | Rosaceae         | <i>Prunus serotina</i> Ehrh.                                                  | 2.8                        |
| Native       | Arborea   | Rosaceae         | <i>Taxodium mucronatum</i> Ten.                                               | 2.1                        |
| Native       | Arborea   | Asparagaceae     | <i>Tecoma stans</i> (L.) Juss. ex Kunth                                       | 1.4                        |
| Non-native   | Arborea   | Pinaceae         | <i>Pinus greggii</i> Engelm. ex Parl.                                         | 14.9                       |
| Non-native   | Arborea   | Anacardiaceae    | <i>Schinus molle</i> L.                                                       | 9.2                        |
| Non-native   | Arborea   | Bignoniaceae     | <i>Jacaranda mimosifolia</i> D.Don                                            | 3.5                        |
| Non-native   | Arborea   | Cupressaceae     | <i>Cupressus spp</i>                                                          | 3.5                        |
| Non-native   | Arborea   | Myrtaceae        | <i>Eucalyptus spp</i>                                                         | 2.8                        |
| Non-native   | Arborea   | Pinaceae         | <i>Abies spp</i>                                                              | 2.1                        |
| Non-native   | Arborea   | Oleaceae         | <i>Fraxinus uhdei</i> (Wenz.) Lingelsh.                                       | 1.4                        |
| Non-native   | Arborea   | Salicaceae       | <i>Populus spp</i>                                                            | 1.4                        |
| Non-native   | Arborea   | Juglandaceae     | <i>Juglans regia</i> L.                                                       | 0.7                        |
| Non-native   | Arborea   | Rosaceae         | <i>Prunus armeniaca</i> L.                                                    | 0.7                        |
| Non-native   | Arborea   | Leguminosae      | <i>Mimosa tenuiflora</i> Benth.                                               | 0.7                        |
| Non-native   | Arborea   | Leguminosae      | <i>Erythrina spp</i>                                                          | 0.7                        |
| Non-native   | Arborea   | Oleaceae         | <i>Olea europaea</i> L.                                                       | 0.7                        |
| Native       | Shrub     | Cactaceae        | <i>Opuntia tomentosa</i> Salm-Dyck<br><i>Opuntia hyptiacatha</i> F.A.C. Weber | 11.3                       |
| Native       | Shrub     | Asparagaceae     | <i>Agave salmiana</i> Otto ex Salm-Dyck                                       | 9.2                        |

| Distribution | Structure | Family        | Species                                                    | Percentage of mentions (%) |
|--------------|-----------|---------------|------------------------------------------------------------|----------------------------|
| Native       | Shrub     | Cactaceae     | <i>Mammillaria rhodantha</i> Link & Otto                   | 7.8                        |
|              |           |               | <i>Mammillaria magnimamma</i> Haw.                         |                            |
|              |           |               | <i>Ferocactus latispinus</i> (Haw.) Britton & Rose         |                            |
|              |           |               | <i>Lophocereus marginatus</i> (DC.) S.Arias & Terrazas     |                            |
|              |           |               | <i>Cylindropuntia imbricata</i> (Haw.) F.M.Knuth           |                            |
|              |           |               | <i>Echinocereus cinerascens</i> (DC.) Lem.                 |                            |
|              |           |               | <i>Stenocactus crispatus</i> (DC.) A. Berger ex A.W. Hill  |                            |
| Native       | Shrub     | Asparagaceae  | <i>Stenocactus obvallatus</i> (DC.) A. Berger ex A.W. Hill | 1.4                        |
|              |           |               | <i>Agave filifera</i> Salm-Dyck                            |                            |
|              |           |               | <i>Agave inaequidens</i> K. Koch                           |                            |
|              |           |               | <i>Agave lechuguilla</i> Torr.                             |                            |
| Native       | Shrub     | Euphorbiaceae | <i>Agave americana</i> L.                                  | 0.7                        |
|              |           |               | <i>Jatropha dioica</i> Sessé                               |                            |
|              |           |               | <i>Ricinus communis</i> L.                                 |                            |
|              |           |               | <i>Euphorbia radians</i> Benth.                            |                            |
| Native       | Shrub     | Compositae    | <i>Euphorbia indivisa</i> (Engelm.) Millsp.                | 0.7                        |
|              |           |               | <i>Senecio praecox</i> (Cav.) DC.                          |                            |

*Permitted and restricted activities in the SGSP.* Workshop participants listed the activities that they consider should be permitted (Fig. 5) and those that should be restricted (Fig. 6). According to the frequency of mentions with the WordItOut software, permitted activities are related to soil and vegetation conservation, flora and fauna observation, family, and pet recreation; restricted activities include the extraction of natural resources, abandonment of pets, and the introduction of exotic species.

*Identification and classification of problems.* With collective participation, the problem tree was constructed, finding the main problem, its causes (C), and its effects (E). The main problem was the degradation of ecosystems and the loss of plant species (Fig. 7). In the objective tree, the problems were converted into positive actions and the ends (E) and means (M) were identified to find possible solutions. The solution to the problems is the restoration of degraded ecosystems, recovery of displaced species, and protection of endangered species. It is essential to implement an Ecological Land Management Plan as an environmental policy tool (Fig. 8). Likewise, actions must be taken to halt the loss of biodiversity and ecosystem services, reduce environmental pollution, recover the productive capacity of ecosystems, and promote the social wellbeing of the inhabitants.

*Semi-structured interviews.* Of the 141 interviewees, 51% were women and 49% men; 67% were visitors, 13% were residents, 11% were public servants, 5% were professional service providers, 3% were ejidatarios, and 1% were environmental activists (Fig. 9).

Plant species that were once abundant and are now rare include: mesquites (*Prosopis laevigata*), oaks (*Quercus spp.*), pines (*Pinus spp.*), ahuehuetes (*Taxodium mucronatum*), tejocotes (*Crataegus mexicana*), maguey pulquero (*Agave salmiana*), nopal (*Opuntia spp.*) and cazahuates (*Ipomoea arborescens*).

90% are aware of SGSP problems, of which 49% have participated in reforestation activities; however, only 20% have carried out monitoring, inspection, and surveillance activities.

Four priority projects were generated at the results workshop: 1. Restoration with *Prosopis laevigata* and forest sanitation; 2. Soil and water conservation works 3. Restoration of the vegetation cover with native species and agroforestry approach; 4. *Bursera cuneata* as a conservation axis.

The results of the participatory diagnosis provide an overview of the process experienced by the community and promote dialogue between the intervention-research team and the users of the territory (Espinoza et al. 2015). It is presented as a dual-purpose tool: it allows entering the community, connecting with its needs establishing bonds of trust, and generating information to plan interventions (Mori 2008). Based on Mitjans and Pacheco (2017), it is necessary to consider that the causes of ecosystem deterioration are mainly anthropogenic, so the participation of social actors is desirable for the rehabilitation of degraded ecosystems.

Participatory research allowed the members of the socioecosystem to know and understand the state of natural resources and, therefore, to find short-, medium-, and long-term solutions for the benefit of future generations (Montagnini et al. 2008). Thus, solutions to socioecosystem problems must be based on the conditioning factors of the political and economic context (Van Dam 2000). On the other hand, society participation allows the development of management plans for the improvement and approval of activities. This generates continuous progress in the management and conservation of natural resources and, as a consequence, sustainable development (Correa 2006). This methodology builds in the future participatory democratic processes that allow for "bottom-up" decision-making, according to the interests, needs, and aspirations of the community, considering that the community is the one who experiences the effects and consequences of any action, who knows its living conditions, as well as the relationship with natural resources and the environment (Luján-Álvarez et al. 2021; He et al. 2015).

## Conclusion

Through the use of participatory community tools, native flora and fauna species of interest for the restoration, conservation and protection of natural resources can be identified and used as a basis for the development and implementation of priority projects. This method generates reliable and socially acceptable technical knowledge, which can be used to develop restoration, conservation, protection, and productive reconversion actions in degraded forest areas. In the territory of the Sierra de Guadalupe it is feasible and desirable to establish agroforestry and silvopastoral projects considering the forest species selected in a participatory manner, with the purpose of contributing to biodiversity and generating ecosystem services, which give continuity to the development of projects for the rescue of the present ecosystems, combining the efforts of all the actors involved.

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Figures

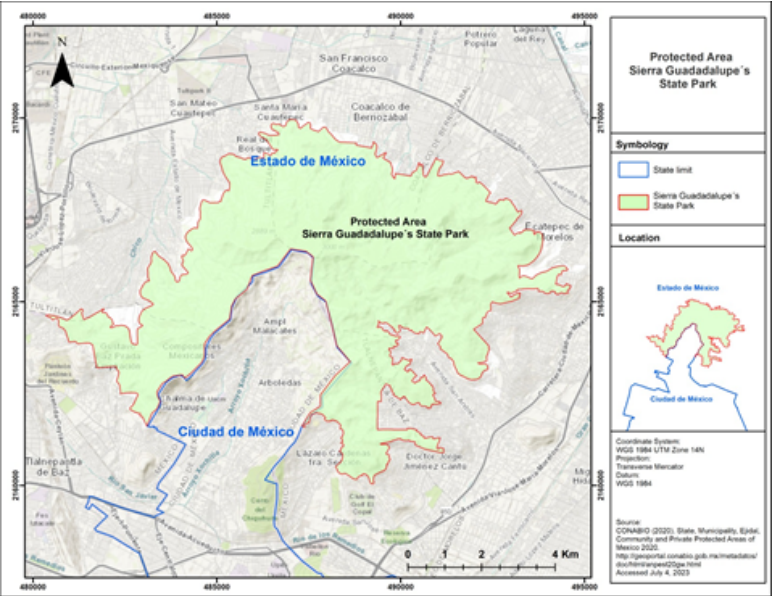


Figure 1  
Location of Sierra de Guadalupe State Park, Mexico

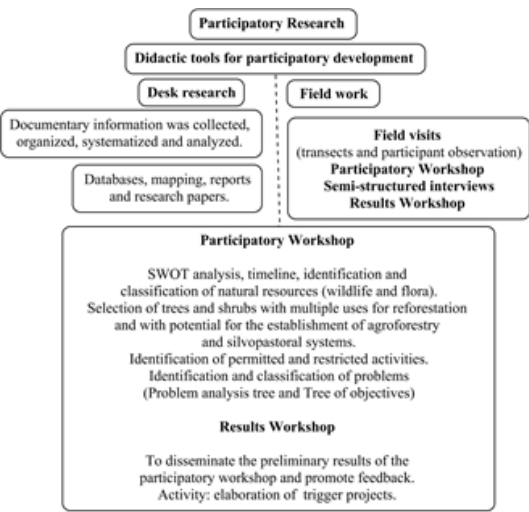


Figure 2  
Methodological scheme of the participatory diagnosis in Sierra de Guadalupe State Park, Mexico



Fig. 5.Word cloud of permitted activities in Sierra de Guadalupe State Park, Mexico (WordItOut)



Figure 5

Fig. 6. Word cloud of restricted activities in Sierra de Guadalupe State Park, Mexico (WordItOut)

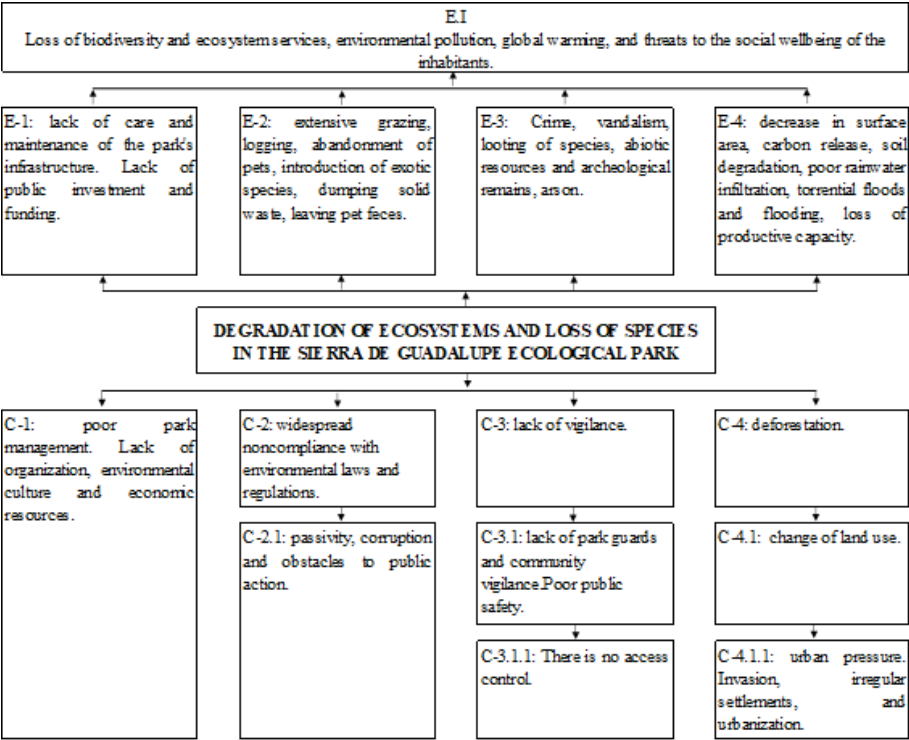


Figure 6

Fig.7. Problem tree describing the current situation of the Sierra de Guadalupe State Park, Mexico

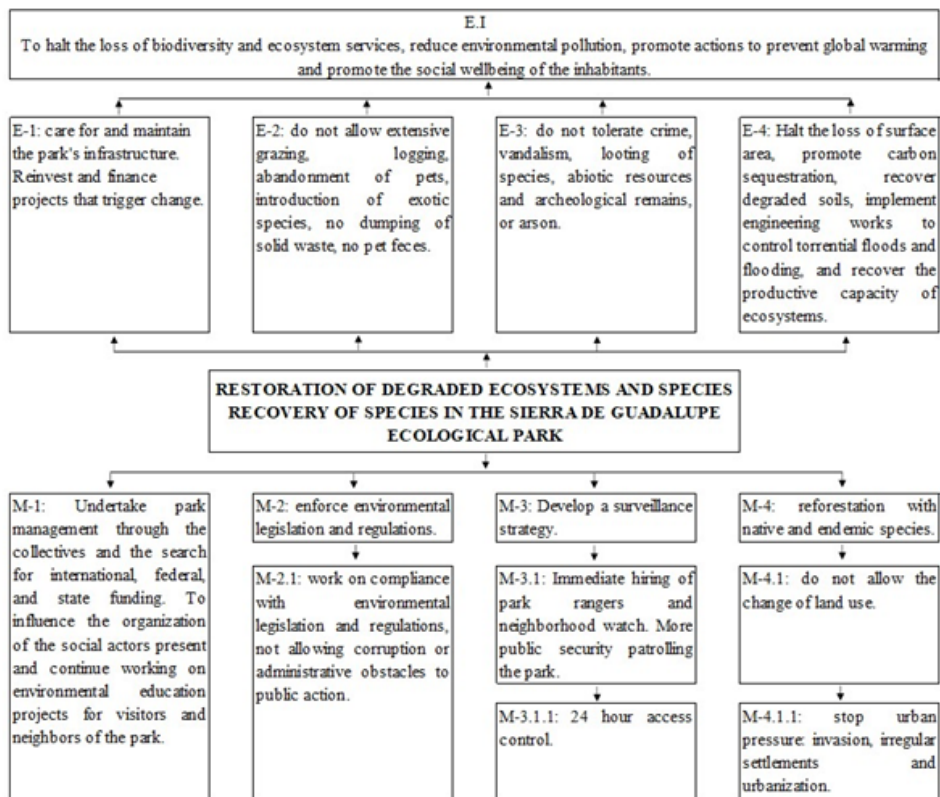


Figure 7

Fig. 8. Objective tree presenting possible solutions to the problems of Sierra de Guadalupe State Park, Mexico

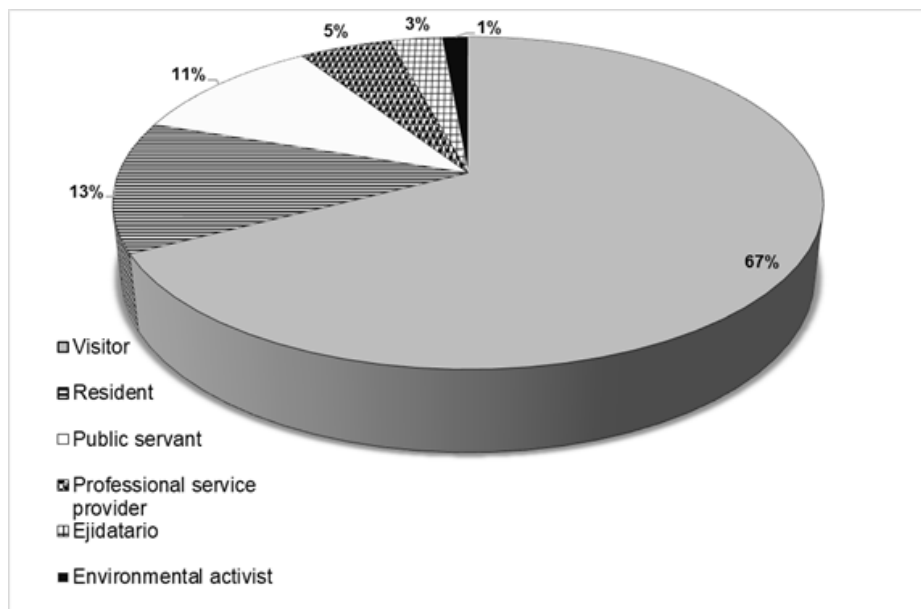


Figure 8

Fig. 9. Social actors present in Sierra de Guadalupe State Park, Mexico