CHAPTER IV

DESCRIPTION OF THE REGIONAL ENVIRONMENTAL SYSTEM AND SIGNALING TRENDS OF THE DEVELOPMENT AND DETERIORATION OF THE REGION

IV.1. Demarcation of the Regional Environmental System (SAR, as per initials in Spanish)

The project being discussed is located in the northern part of the State of Michoacán. Its right of way extends to three municipalities (Panindícuaro, Jiménez y Zacapú). In accordance with the Secretaría de Planeación y Desarrollo Estatal Planning and State Development Secretary), these municipalities fall within the Bajío II region, and it represents 8% of the State's surface. Given that the objective of this regionalization is administrative and not environmental management or ecologic functionality, it was determined to crate the Regional Environmental System and it evaluated the project's environmental impact, as s described in the following paragraphs.

In order to set the limits on the regional environmental system (SAR, as per initials in Spanish) the cartographic information was examined on the municipal division, geology, layout, hydrology, edaphology and vegetation and use of soil (Letters A through 8, Annex 2).

Although the macroscale of the project is located in an area called by the Neovolcanic Axis, at mesoscale the location is distributed into three geomorphologic units, at the foot of the hill, rolling hills and mountain (skirt). The location is found between two elevations, to the east, the Brinco del Diablo Hill, 2540 m high. To the west, the El Fresno Hill (2300 m) (Figure IV.1).

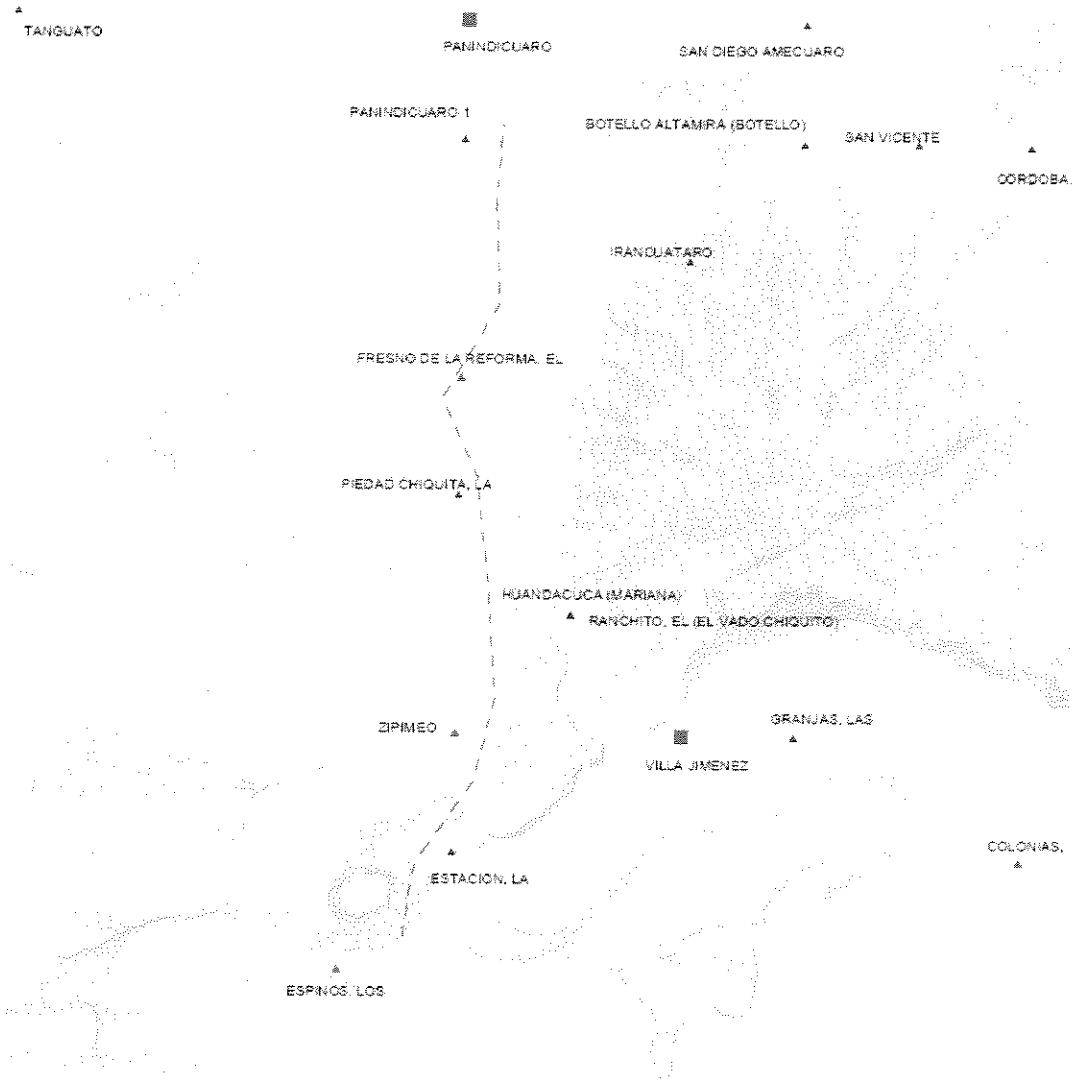


Figure IV.1. Level Curves close to the Location

In accordance with INEGI (Figure IV.2), the predominant vegetation is irrigation agriculture, while oak trees grow on the hills with secondary vegetation (and induced grassland on the El Fresno Hill, that has softer slopes).

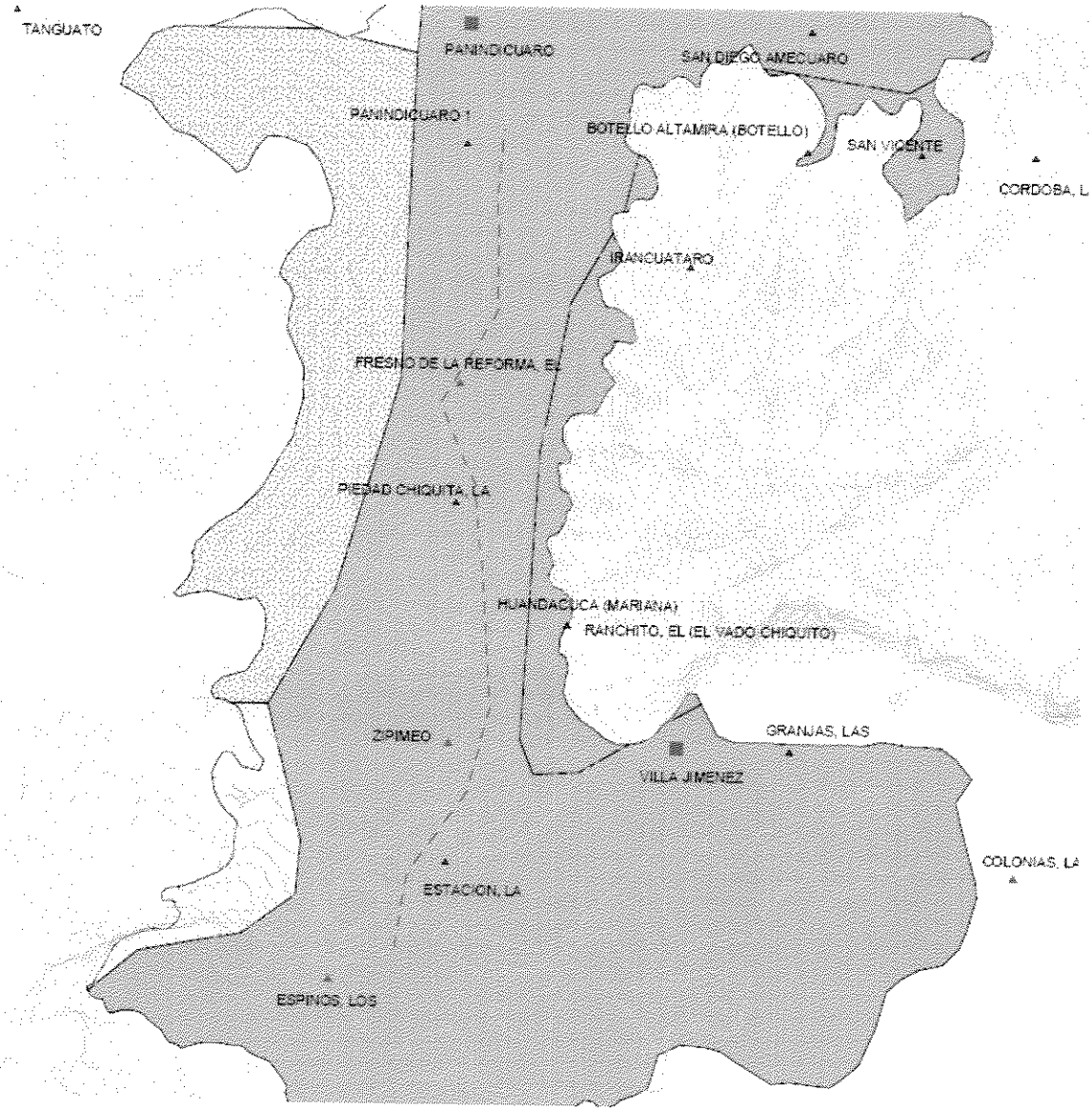


Figure IV.2. Use of soil and vegetation (INEGI).

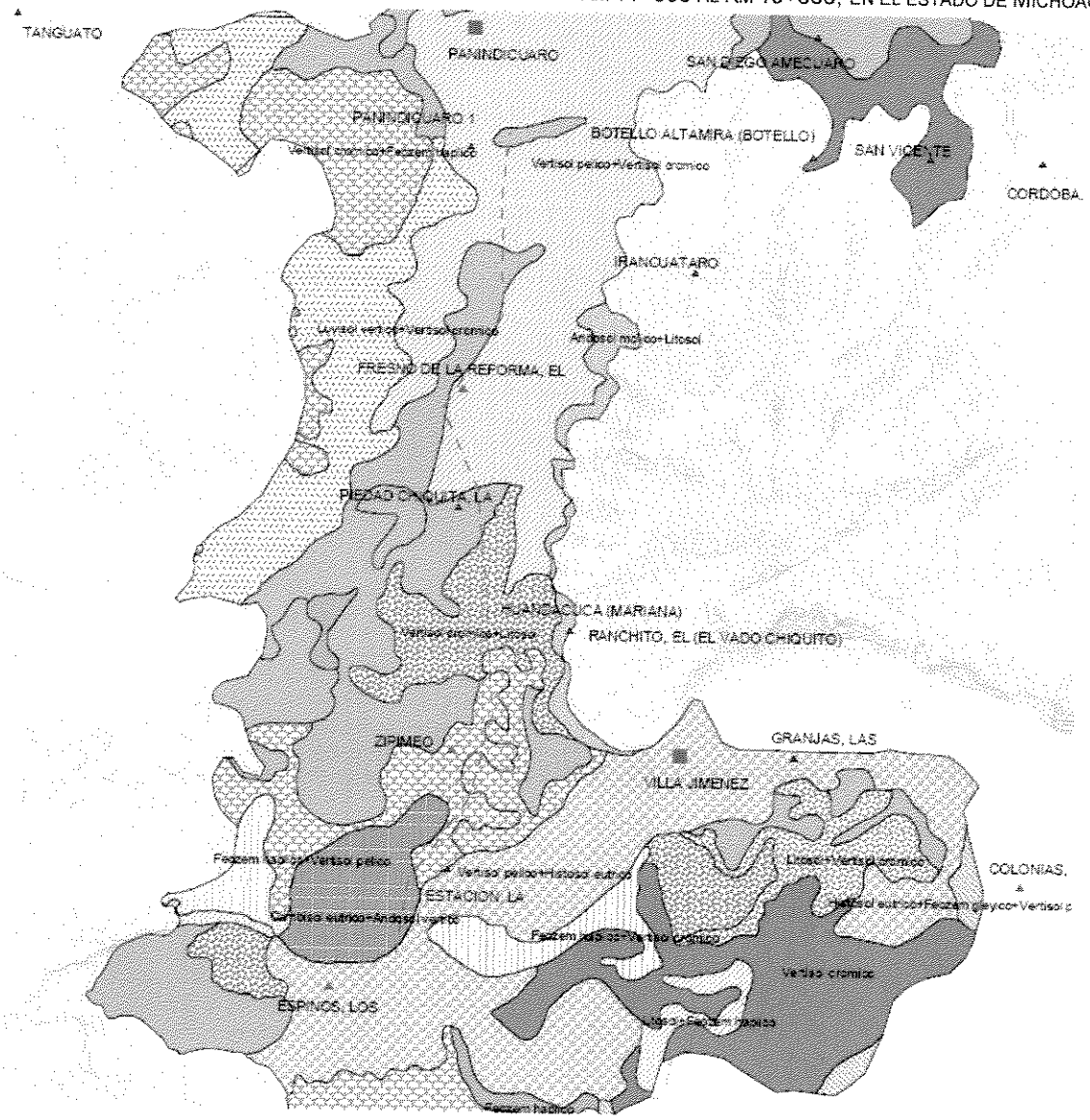


Figure IV.3. Edaphology (INEGI).

It was determined that the properties that would better allow setting the limits of the regional environmental system are: vegetation (Figure IV.2), soil (Figure IV.3) and altitude (Figure IV.1).

Therefore, the regional environmental system (SAR, as per initials in Spanish) is formed by the set of vegetation polygons that are cut by the location, taking the following into consideration:

To the north, from west to east the limit is set by the edge between the oak tree forest found at the south of the foot of the mountain and the seasonal agriculture and induced grassland, and it continues by the irrigation agriculture land edge and, at the northeastern end, it goes a bit into the San Vicente village, where INEGI (1986) states that there is an oak tree forest with secondary vegetation, to the east of the location.

To the east, from north to south, you follow the 2000-meter high spot height of the Brinco del Diablo Hill. When you get to Villa Jiménez, the polygon extends to the east to follow the contour of the association of the vertisol pellic + hystosol eutric soil type, and then the chromic vertisol, and finally and association of the vertisol chromic + feozem haplic type. To the west, from north to south, you follow the 2000 m height of the El Fresno Hill, the verticol pellic soil type, that is included in a small polygon of the haplic (next to the Hola la Alberca), one of vertisol pellic and you go round the lacustrine soil to the southeast of the Los Espino Village.

The resulting polygon is presented in Figure IV.4. In this manner, SAR's polygon has an irregular shape that approximately maintains the orientation of the location and includes all the vegetation types and soils cut by the location and also that adjacent to it. The objective of SAR's demarcation is to determine the functional ecology unit in which the project is enclosed.

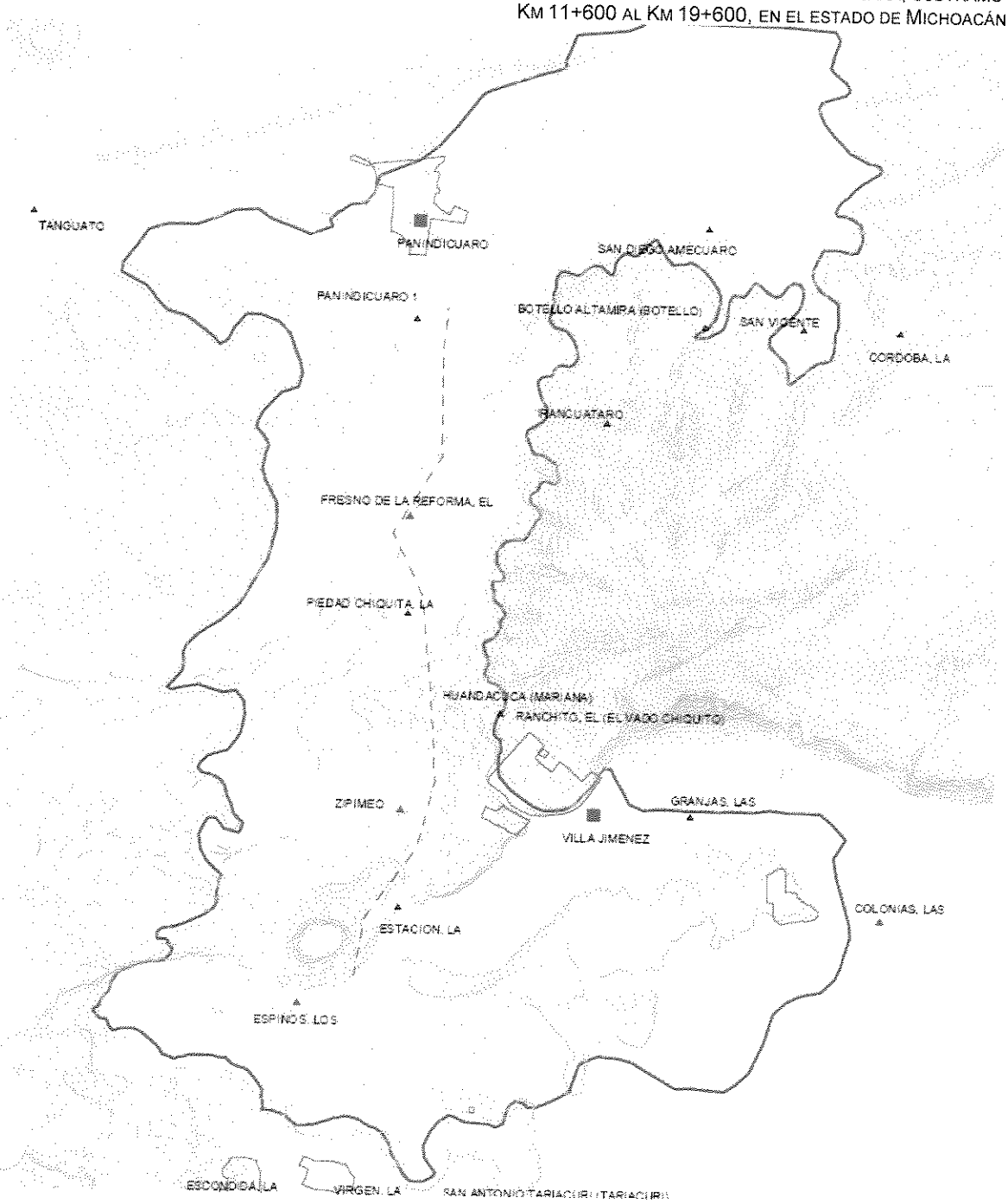


Figure IV.4. SAR's demarcation, based on the vegetation and use of soil, edaphology and altitude.

IV.1.1 SAR's synthetic description

SAR has a 5,554.43 Ha surface. Below you will find the summary of SAR's surfaces for different cartographic attributes: municipal division, climate, superficial geology, edaphology and vegetation (according to INEGI and a national[1] forestry inventory).

Table IV.1. Distribution of SAR's surfaces in accordance with administrative, superficial geology and edaphic types criteria.

Administrative Criteria

Surface (Ha)	Surface (%)	Municipality
342.334	6.2%	Zacapú
2,783.810	50.1%	Jiménez
2,428.285	43.7%	Panindícuaro

Climate

Surface (Ha)	Surface (%)	Climate Type
4719.248	85.0%	C(w1)
817.622	14.7%	(A)C(w1)
17.559	0.3%	C(w2)

Surface Geology

Surface (Ha)	Surface	Family	Classification
256.455	4.6%	Igneous rocks	Andesite
8.437	0.2%	Igneous rocks	Volcanic Device
1441.318	25.9%	Igneous rocks	Basalt
19.618	0.4%	Basalt Soil	Volcanic breach
686.455	12.4%	Soil	Alluvium
1120.126	20.2%	lacustrine soil	
12.270	0.2%	Residual Soil	

[1] The calculation record that includes the superimpositions and the application of criteria is presented in Annex 5, only in digital format, in Arc View shape files.

Types and edaphic associations

Surface (Ha)	Surface (%)	Code	Type of soil
137.365	2.5%	Be+Tv/2	Cambisol eutrico+Andosol vertico
42.191	0.8%	Hh/2	Feozem haplic
80.506	1.4%	Hh+Vc/2	Feozem haplico+Vertisol Chromic
52.452	0.9%	Hh+Vp/2	Feozem haplico+Vertisol pellic
50.542	0.9%	I+Hh/2	Lithosol+Feozem haplic
120.541	2.2%	I+Vc/3	Lithosol+Vertisol chromic
383.021	6.9%	Lv+Vc/3	Luvisol vertico+Vertisol chromic
28.178	0.5%	Oe+Hg+Vp/2	Histosol eutric+Feozem Gleyic+Vertisol pellic
60.468	1.1%	Tm+I/2	Andosol mollic+Lithosol
520.286	9.4%	Vc/3	Vertisol chromic
625.277	11.3%	Vc+Hh/3	Vertisol chromic+Feozem haplic
274.980	5.0%	Vc+I/3	Vertisol chromic+Lithosol
4.555	0.1%	Vc+Lv/3	Vertisol chromic+Luvisol vertic
1506.227	27.1%	Vp/3	Vertisol pellic
744.232	13.4%	Vp+Oe/3	Vertisol pellic+Histhosol eutric
923.605	16.6%	Vp+Vc/3	Vertisol pellic+Vertisol chromic

Table IV.2. Distribution of vegetation at SAR (INEGI and national forestry inventory)[2].

National forestry inventory % Vegetation	Cartography of the use of soil and vegetation % Vegetation
64.8% Irrigation agriculture (includes occasional irrigation)	78.6% Irrigation agriculture
20.8% Seasonal agriculture with annual crops	2.6% Seasonal agriculture
4.8% Induced grassland	0.6% Seasonal agriculture and induced grassland
3.8% Subtropical bushes	0.1% Subtropical bushes
0.6% Subtropical bushes with secondary shrub-like and herbal vegetation	0.2% Subtropical bushes with secondary vegetation
2.5% Human Settlement	
2.7% Oak tree forest with shrub-like secondary and herbal vegetation	4.8% Oak tree forest with secondary vegetation
0.0% Oak tree forest	13.0% Oak tree forest with secondary vegetation and induced grassland

There are significant discrepancies when comparing the surfaces of types of vegetation. To some degree, the differences can be partially explained due to the difficulty in obtaining an accurate classification and some of the air photography or satellite imaging, the coverage of the clouds, the scale differences, the classification criteria differences and the changes caused

2 The field results (fifteen sampling sites and three census) suggest another interpretation. The analysis will be presented in the corresponding Vegetation, and Characterization of the Natural Environment section.

and the changes caused by the period of time elapsed between the two attempts to generate cartography. In this case, the totals for the agricultural and induced grassland surface are quite close. The differences are bigger for the subtropical scrubland surface (in a 38:1 ratio), oak tree forests and human settlements. The field results, to be presented and discussed subsequently in this Chapter, will allow us to give a clear definition of the current situation. For the purpose of this summary, we can state tat in 80% of the SAR area, agricultural activities are performed, and in approximately 5% there is induced grassland and in approximately 2.5% there are human settlements, and therefore the anthropogenic influence is big and disseminated. Despite its reduced extension, natural vegetation is important because it represents a wild fauna habitat, specially for the species that are intolerant to disturbances.

IV.2. Characterization and analysis of the environmental Regional System

IV.2.1. Abiotic Media

CLIMATE

There are three different climate types in SAR. Two of semi-hot type and one is a mild climate. Following the Garcia (1988) classification, we have the (A)C(w1), C(w1), and C(w2) climate types. The mild C(w1) is found in 84.96% of the surface, and its mean annual temperature is between 12°C and 18°C; the one in the coldest month fluctuates between -3°C and 18°C and the warmest month temperature is under 22°C. Regarding rainfall, it is sub humid with annual records of 200 to 1,800 mm. Rainfall in the driest month is between 0 and 40 mm. Annual summer rain represents between 5% to 10% and a P/T between 43.2 and 55.

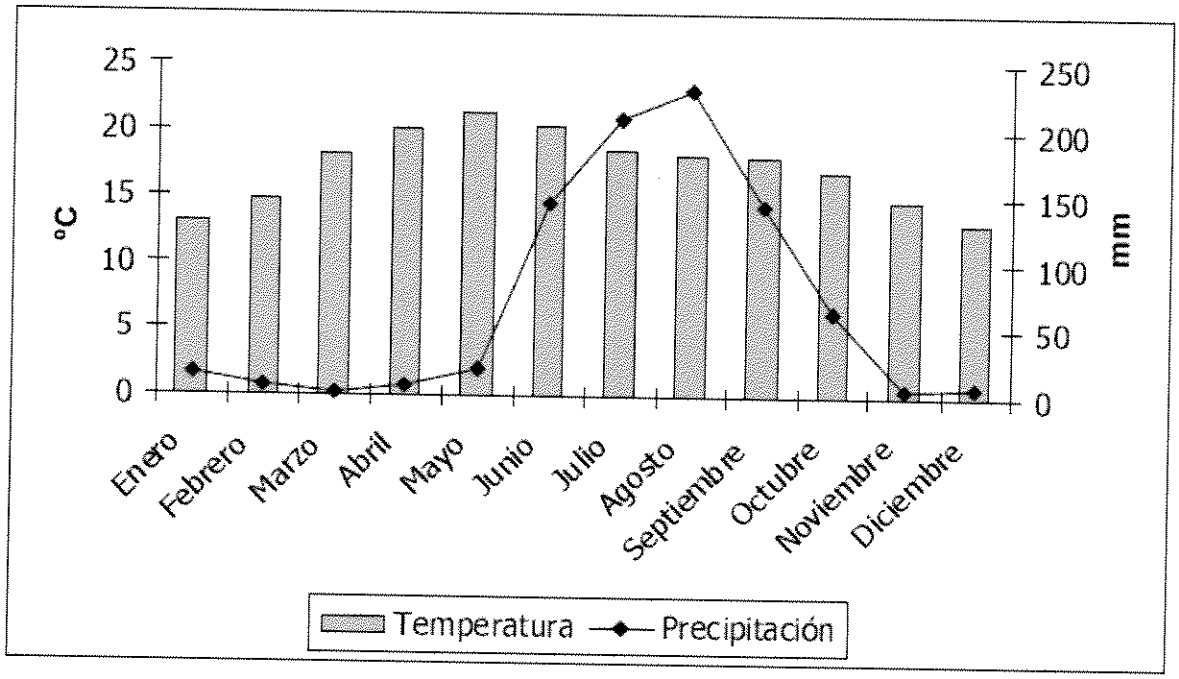
The semi warm type climate (A)C(w1) includes 14.7% of SAR. It is characterized for being semi warm, mild-sub humid. The annual mean temperature is > 18°C, and the colds month's temperature is < 18°C, while the temperature in the hottest month is > 22°C. Annual rainfall is between 500 and 2,500 mm, and the one in the driest month is between 0 and 60 mm. The annual summer rain's are between 5% and 10.2%.

In 0.3% of SAR the climate type is distributed C(w2). It is also semi warm, but more sub humid than C(w1), with a P/T higher than 55.

In order to make a more accurate characterization of the climate conditions, the information from the Panindícuaro (19°59'N, 101°46'W; 1,633 m de altitude) meteorological conditions was analyzed. The maximum mean temperature happens in May (21.2°C), and the minimum in January (13.1°C). The heaviest rainfall happens during the four summer months (June through September), with the maximum report in the month of August with 229.5 mm. During the rest of the year the rain is not less than 5 mm and therefore there are relatively high humidity and mild temperature conditions. The disposal of fresh water favored clearing of the land for agricultural purposes. Nevertheless, there are still some original species (gallery forest) on the boundaries of the fields.

Naturals Risks

The effect of meteorological phenomena that may cause natural risks on the works' construction activities, are of extremely low influence. At SAR the environmental temperature does not allow the setting of conditions for frost or snow. The frequency of hail is between 0 to 2 days a year. Directly for the delimited area there are no records of the occurrence of this kind of phenomena, and therefore only the frequency mentioned previously is taken into consideration. Consequently, regarding SAR, the climate risks are minimum when constructing works.



January, February, March, April, May, June, July, August, September, October, November, December

Temperature Rainfall

Figure IV.5. Average temperature and standard normal rainfall.

GEOLOGY AND MORPHOLOGY

Geology

From the geological point of view, SAR is located on the physiographic province of the Neovolcanic Transversal Axis in the sub-province of the Mountain Ranges and "Bajío" in Michocacán. Regarding SAR's lithology, it is formed as follows: *alluvium* (44.74% of SAR), *andesite* (4.63%), *basalt* (41.45%), *and volcanic basaltic breach* (9.17%). On one hand the alluvium is a sedimentary dendrite non-consolidated basic type rock. Gravel, sand, lime and clays form it. Morphologically, they are found forming alluvial fans and plains, filling valleys. Specifically, at SAR it is found in most of the area, because at the foot of the hill it is dominant. Due to the nature of its components it sometimes presents two areas, one of high permeability and another one low.

In the case of andesite, it represents the lavic morphology of the Middle Tertiary; the composition is essentially of the andesite type. In highly restricted locations, the silica or potassium content increases and thus changes these rocks respectively into traquiandecite dacites (latite). In general terms, andesites have a dark gray, greenish and reddish color with streaks. The structure varies between spills and highly eroded volcanic cones; these are compact rocks with porfidic texture generally microlithic and as special constituents, of plagiclass composition (andesinaoligloclass). Andesites in SAR present a topographic expression in the form of hills and mountains of medium elevation generally with steep topography. Because of their composition, andesites have a low to null permeability, depending upon the rock cracks. They are important areas of runoff of SAR and small infiltration zones from cracks, and this benefits the aquifer in the area.

In turn, basalt presents a vesicular structure, tonsil like and compact, and this unit shows failure of normal layers. It is found covering sedimentary and intrusive igneous rocks of the Cretacic, and acid volcanic rocks of the Oligocene-Miocene and underlies clastic deposits of the Quaternary. This unit is characterized because it presents forms of lavic spills, lavic cascades and volcanic cones. In its hydrogeology it acts as a spillover zone and in some parts as a reloading zone. Permeability from fractures is high, and this generates significant contributions to the aquifer. As the case may be, the *volcanic basalt breach* is present in well marked out areas of SAR. It is characterized because it is the result of volcanic activity, is formed by an alternation of basalt spills and volcanic breach. In itself, the morphology is of plateaus. From the hydro geologic standpoint, this unit has low permeability.

Geomorphology

SAR is located in the physiographic sub-province of what is considered to be the Hills and "Bajíos" (low lands) from Michoacán. This sub-province is characterized by the presence of volcanic elements formed by igneous rocks, rolling hills formed by igneous rocks and *foothills* formed by sedimentary rocks.

The first geomorphologic unit (*volcanic mountains*) is characterized by volcanic-erosive mountains and are slightly to moderately dissected and they can be formed with dacite, basalt andesites, basalts, ignimbrite, rhyolite and gabbros: of these at SAR, only those formed by basalt are presented. Regarding the *rolling hills*, they are not defined and therefore you can find two types: volcanic-erosive or volcanic denudatives. Also, they vary and are from lightly to severely dissected; and they are formed by andesites, tufas, dacite and drop deposits (volcanic ashes). At SAR they are exclusively formed by andesites.

Finally, the *foothills* are the most extensive at SAR. This is a system of tilted prairies at the foot of the mountains and encircling mounting elevations, formed by the accumulation of dentrites carried from the high portions and deposited through dejection cones and detritus, which coalescence and over position allow growth in a vertical sense (sedimentary accretion) and spatial.

Seismicity

From 85 to 90 % of the seisms or earthquakes that happen in Mexico are produced in the subduction zone of the tectonic plates off the Pacific coast, from Puerto Vallarta, in the state of Jalisco, to Tapachula, in the state of Chiapas. In accordance with the seismic regionalization, SAR is located in region B. This is an intermediate zone where seisms are not so frequently registered or are areas affected by the high accelerations but that do not exceed 70% of the soil acceleration, the seismic hazard is low and there is a 0.14 index. The area where SAR is located is not in the simulation of return periods, and therefore SAR is not considered to be at a specially risky situation due to seisms.

Slides and landslides (Mass movements)

At SAR the slopes are soft and do not present a significant mass removal. Therefore, it is not considered to be a mass movement risk.

Erosion Processes (Water)

In general terms, basalt is one of the pyroclastic materials of higher susceptibility to water erosion, as happens in the project's area. In the regionalization of the Lerma-Chapala basin, the project is located in severe water erosion areas.

In this regard, the dominant production systems have detonated some soil degradation types that slowly undermine the integrity of the Melchor Ocampo basin (where SAR is located). The main processes correspond to superficial water erosion, declination of fertility, erosion by rills, salinity and eolic erosion. The most extended is the superficial water erosion, which affects a 471.5 km2 surface, the equivalent to 21% of the total sub-basin. This process is basically found in the rolling hills and foothills' units. This erosion is associated to the seasonal agricultural and induced grassland zones.

EDAPHOLOGY

In accordance with the classification of soils of FAO-UNESCO (1990), at SAR you can find 10 types of soils, based on a FAO-UNESCO classification, distributed in 16 edaphic associations (Table IV.1), There is no dominant one amongst them. However, the *Vertisol pellic, Vertisol chromic and their association* cover 71.35% of SAR. Other outstanding associations are: Vertisol chromic +Feozem haplic (8.77%) and Luvisol vertico+Vertisol chromic (6.94%).

Table IV.3. Edaphic Characteristics per association type.

Edaphic Association	Texture	Physical F.	Fertility	Fragility	Erodab.
Mollic+Lithosol Andosol	Medium	Lithic	Low	High	High
Eutric+Andolsol Vertic Cambisol	Medium	Lithic	Medium	High	High
Feozem haplic	Medium	Lithic	High	Moderate	Moderate
Feozem haplic+Vertisol Chromic	Medium	Lithic	High	Moderate	Moderate
Feozem haplic+Vertisol pellicq	Medium	Lithic	High	Moderate	Moderate
Histosol Eutric+Feozem Gleyic+Vertisol pellic	Medium	Lithic	High	Moderate	Moderate
Lithosol+Feozem haplic	Fine	Stony	High	Medium	High
Lithosol+Vertisol chromic	Fine	Stony	Low	Low	Low
Luvisol vertic+Vertisol Chromic	Fine	Duric	Low	High	High
Vertisol Chromic	Fine	Stony	Low	Moderate	Moderate
Vertisol Chromic+Feozem haplic	Fine	Stony	Medium	Moderate	Moderate
Vertisol chromic+Lithosol	Fine	Stony	Low	Moderate	Moderate
Vertisol chromic+Luvisol vertic	Fine	Stony	Low	Moderate	Moderate
Vertisol pellic+Histosol eutric	Fine	Stony	Medium	Moderate	Moderate
Vertisol pellic+Vertisol chromic	Fine	Stony	Low	Moderate	Moderate

Table IV.4. Distribution of the areas occupied by each association in SAR.

Edafic Association	Surface (%)
Pellic vertisol	37.19
Pellic vertisol+chromic vertisol	25.35
Vertisol chromic	8.81
Vertisol chromic+feozem haplic	8.77
Vertic Luvisol+chromic vertisol	6.94
Chromic vertisol+Lithosol	4.54

Edafic Association	Surface (%)
Pellic Vertisol+Eutric Histosol	1.87
Lithosol+Chromic Vertisol	1.83
Histosol eutric+Feozem gleyic+Pellic Vertisol	0.80
Andosol mollic-Lithosol	0.64
Lithosol+Feozem haplic	0.40
Feozem haplic+Chromic vertisol	0.17
Chromic vertisol+Vertic Luvisol	0.01

In the subsequent paragraphs the general characteristics of the soil types are described. Subsequently, the implications of every association in SAR will be examined.

Mollic Andosol

With loose, immature soils and a more than 50 cm depth, with pH slightly acid reaching on occasions the neutrality, located in a broken topography and of easy erosion getting at times to neutrality, located in a broken topography and of easy erosion characterizing areas where there has been a recent volcanic activity, all of medium texture, present lithic superficial and deep phases. Specifically, the mollic andosol presents a strong structure in its horizon, with saturation of the basis, with a 50% minimum. Asides it may include transition horizons.

Vertic Andosol

This type of soil is used for intensive agriculture, although there is poor phosphate fixation. It presents the same characteristics as the mollic Andosol, with the difference that the sum of the change bases plus the changeable hydrogen is lower than 6 cmol(c)/kg of clay in a sub horizon of B that is located less than a meter deep.

Eutric Cambisol

Soils that are located with broken formation stages, by erosion or cover with layers of materials of breccia and volcanic tufas. The parental material of these soils in the changing horizon is basically formed by layers of volcanic ash, whose chemical weathering generates the formation of the so called "tepetate" (limestone) which are duripans and fragipans, where calcification sheets and veins, silification and ferruginization have formed. The loss of forestry coverage due to inappropriate use of the soil, in slopes always bigger than 6° (12%), favor deep "escorrentias" that erode the edaphic materials of the soil and underground, generating slopes in internal valleys between the mountain units. These soils present high vulnerability to the water erosion, have few possibilities of agricultural or livestock use, restricting it to wild or livestock life with very accurate practices and management.

Haplic Feozem

One of the main features of this type of soil is its good performance. Although they are deep, in some places they are limited by stony or costly phases in its surface area; or by lithic phases and deep lithic in the subsoil. Their color is dark because of the high organic matter content. Also, they

have high nutrient levels. They are of medium textures and come close to being clayish scraps; there is also some fine and thick texture. Its productivity is good, but if they are not well managed, their susceptibility to water erosion is from moderate to high. The flair of these soils is definitively for livestock breeding and agricultural use, of course, with an appropriate management so that they do not loose their fertility.

Feozem gleyico

Unlike the haplic Feozem, the F. gleyco has poor drainage and is soon saturated with water, unless it is well drained. There is ferrous iron in its constitution and this is seen in its dark blue color on a recently exposed surface. The soil supports the scrubland very well, and it also has an excellent agricultural quality.

Eutric Histosol

Histosol soils have as a basis the organic material and they are typical of the areas where there is a great deal of humidity. In agricultural uses, vegetables are harvested with high productivity indices, and the sub-unit in this eutric case has organic matter such as wood fragments, fibers, humus that tends to generate bad odor due to the decomposition of the materials and by their constitution they are acid with medium texture similar to that of the river mud, they have no drainage problems and due to their own nature they tend to degrade and therefore collapse.

Lithosol

The soil is very thin and little developed and therefore they depend directly from the rocky substrate, and present a thick, medium and fine texture class (sandy to sandy and clayish scraps); some present the petrocalcic phase. Drainage is excessive where sands prevail and efficient in soils that have medium and fine textures. They are highly susceptible to erosion. In general terms, these soils are also shallow and frequently degraded or undergoing the degradation process, and they are not apt for agriculture, specially where the land slope is very steep. The potential of these soils is definitively forestry. One of the main degradation causes is deforestation, forest fires and the changes in the use of the land.

Vertic Luvisol

Soils characterized because they present a clayish "B" horizon (argic) resulting from the generation of residual clay in situ, with a cationic exchange capacity of 24 cmol(+)kg-1. These soils are located in slope land and highlands up in the mountains and they are forestry land that have suffered for a long period of time the washing of the bases and have sesquioxides of iron and aluminum concentrations, from which spectacular reddish dull and brilliant yellow colors derive; they are also characterized by the broad and deep drying cracks and deep duric phases. These soils have an essentially forestry vocation and they are highly vulnerable to water erosion at the deforested sites and present erosive forms of big and deep rills that are very hard to control and restore.

Chromic Vertisol

Soils found in mild and warm climates, in zones where there is a marked dry season and another marked rainy season. There is a small spot with this kind of soil to the northeast of SAR (Letter 4, Annex 2). The Chromic vertisols are characterized by the broad and deep cracks that they have

during the dry season. These are highly clayish soils, frequently black of gray in the Center and Eastern part of México and reddish browns in the North. These soils are sticky when they are humid and very hard when they are dry and generally they have little susceptibility to erosion.

Pellic Vertisol

The pellic vertisol is a black to dark gray color, which is characterized as it presents broad and deep cracks in the dry season. The soil is very clayish and their utilization in agriculture is quite large varied and productive. These are very clayish soils and broadly used in varied and productive agricultural practice. Generally these soils are fertile, but they do have some managing problems since their hardness make farming the land difficult and they frequently have flooding due to poor drainage (SPP, 1981).

Table IV.5. Implications of the geology, geomorphology and edafology in SAR.

Unit	Lithology	Geomorphologic Unit	Edafologic Implications for SAR
Alluvium	Foothill	Haplic Feozem Haplic+Pellic Vertisol Vertico Luvisol + Chromic Vertisol Chromic Vertisol Chromic Vertisol +Haplic Feozem Chromic Vertisol +Lithosol Vertisol Pellic Vertisol Pellic Vertisol+Eutric Pellic Vertisol+Chromic Vertisol	These areas occupy 44% of SAR's area and they care found in the low land to the north and center of SAR. There is an intensive water erosion in these areas with a strong trend to formation of rills and loss of soil. The verisol soils (chromic and pellic) with their corresponding edafic associations prevail in these areas (more than 75%), and this is associated to the agricultural zone in the area. However, they form a difficult to manage zone due to flooding that the vertisols favor (due to their high content of expandable clays).
Andesite	Rolling hills	Mollic Andosol+Vertisol Chromic Vertisol+ Haplic Feozem Chromic Vertisol +Lithosol Pellic Vertisol Pellic Vertisol+Eutric Histosol Pellic Vertisol+Chromic Vertisol	Their distribution is very limited in the east zone of SAR, and they occupy 4.63%. These areas are of low to null permeability but high draining. The soils in this area are basically andosols and vertisols, both in combination with lithosol; histosol is found in hollow areas. These soils are constantly washing, even more than in those areas where there has been a cover change. However, until today these rolling hills have a natural tropical forest cover, caducifolio (Btc) always with secondary elements.

Unit Lithological	Geomorphologic Unit	Edafological Unit	Implications for SAR
Basalt Basalt Volcanic Breccia	Volcanic Mountains	Eutric Cambisol+ Vertic Andosol Haplic Feozem+ Chromic Vertisol	In general, what correspond to basalt (basalt and basaltic breccia) take a total of 51.12% of the SAR area. This associated to the volcanic mountain

Halic Feozem+Pellic Vertisol Eutric Histosol+ Gleyic Feozem + Pellic Vertisol Litosol+Chromic Vertisol Vertic Luvisol+Chromic Vertisol Chromic Vertisol Chromic Vertisol+ Haplic Feozem Chromic Vertisol +Lithosol Chromic Vertisol+ Vertic Luvisol Pellic Vertisol	unit, generates high draining areas and low infiltration. These are systems with great weathering, and thus forms conglomerates in the low areas. In the mountain unit, the association of cambisol with andosoles prevails, and these are high vulnerable soils to water erosion and of restricted agricultural use. Despite the fact that a considerable portion has scrubland and forest vegetation, in another area there are small agricultural areas.

HIDROLOGY

SAR is located in the Administrative Region VIII Lerma-Santiago, that includes the Hydrological Region No. 12 that corresponds to the Río Lerma-Chapala basin (total surface 53,591 km2). Of it, SAR is found in the Melchor Ocampo sub-basin that is considered an exploitation area (Table IV.6). SAR is distributed into two micro-basins of this sub-basin, Río Angulo and Villa Jiménez (58% and 42% of SAR).

From Km 13+700 through km 19+600 of the location, corresponds to the micro-basin of the Río Angulo (the central and northern part of SAT). While from km 11+600 through km 13+650 corresponds the micro-frequency of Villa Jiménez.

Table IV.6. General Characteristics of the Melchor Ocampo Sub-basins.

Characteristics	Sub-basin Melchor Ocampo
Total Surface(km2)	2,205.26
Collection and Transportation[3] Zones(km2)	1,505.22
Emission[4] Zones	81.30
Predominant use of the resource	Agriculture/Conservation
Natural Value	High

Superficial Hydrology

At SAR there are a series or intermittent streams and two perennial ones, the River Angulo and the Arroyo Grande. The intermittent streams located to the East of SAR have a radial drain pattern, while the perennial ones are of the dendrite type. Specifically, wastewater, oil and industrial wastes, asides from presenting a high content of organic matter and hydrocarbons from municipal discharges from Zacapu and Celanese pollute the Angulo River. The river dumps into the Laguna de Zacapu, and this causes the eutrofization of the body (Table IV.5).

There is little information for Arroyo Grande. It is used for irrigation purposes and it also dumps into the Laguna de Zacapu. The site crosses several points in these rivers and an intermittent

stream (Table IV.8). To date, there is no specific information of flow volume and drain from these streams.

On the other hand, at SAR there are three lagoons fed by intermittent rivers. The lagoons are: Laguna Ururuta, Laguna San José, and Laguna Cofradía. The first two are intermittent and the Laguna Cofradía is perennial of approximately 8.7 Mm^3, and collects the escorrentía of the small intermittent affluents of the area.

3 Is the part of the basin that in principle is in charge of getting most of the water that comes into the system, and also to transport the water coming from the head zone. This zone may be considered to be a mix since in it water masses of different physical-chemical characteristics converge.

4 Is characterized for being the area that sends towards the biggest current the water coming from the other two functional areas.

Table IV.7. Water Characteristics of the River Angulo.

Water Characteristics	Values in Mm^3
Natural or "virgin" drain by own basin	284.0
Return	0.8
Imports	0.0
Exports	0.0
Drain downstream	172.1
Availability	0.0
CLASSIFICATION	Deficit

Table IV.8. Crossing of drain through the location.

Affluent	Contour
Intermittent stream	Km 13+145
	Km 14+610
Big stream	Km 16+680
	Km 17+590
	Km 17+700
	Km 17+845
Río Angulo	Km 17+980

Underground Hydrology

All the Lerma-Chapala sub region is in an unfavorable reloading and extraction of the aquifers situation (CNA, 2002)

The Pastor Ortiz-La Piedad aquifer, where SAR is located, occupies nine municipalities from the territorial standpoint, and it s one of the most overexploited aquifers in Michoacán, and it is the second one at state level.

From October 20, 1987, this aquifer, like the rest in the state of Michoacán, is in closed condition for an indefinite period of time, for the lighting, extraction and use. It allows limited extractions for domestic, industrial, irrigation and other purposes. To date no water reserve zone has been decreed for specific use. It should be mentioned that for some authors this aquifer is considered to have two units (Table IV.9). However, the CAN considers them t be a single unit due to the underground interconnection.
Regarding its structural characteristics, it has a low to moderate permeability due to two factors: faults and fractures and the geologic structure.

On the one hand, the faults on the plinth allow the aquifer to reload, just like the basalt areas, and the problem is that it also allows pollutants to infiltrate. On the other hand, the alluvium content areas are the ones that to a great extent prevent the immediate reloading of the aquifer.

This aquifer is deemed to be of the free type due to its geological characteristics.

Table IV.9. Hydrological characteristics of the aquifer directly involved in the project (CNA, 2002).

Characteristics	Aquifer Pastor Ortiz	Aquifer La Piedad
Recharge (mm3)	28,594	50,700
Extraction (mm3)	51,584	55,715
Availability	-22,990	-5,015
Condition	Over exploited	Over exploited

IV.2.2 Biotic Factors

VEGETATION

A little bit more than 80% of SAR's surface is occupied by irrigation or seasonal agriculture,. In the remaining surface there are human settlements, induced grassland and also natural vegetation is distributed of basically three types, in accordance with the Rzedowski (1978) nomenclature: Caducifolio Rain Forest (with or without secondary vegetation), Bosque de Galería and aquatic[5] Vegetation. Native vegetation is alternated with agriculture fields, both seasonal as well as irrigation. In the foothill zone, agricultural fields in the Zacapu Swamp (lacustrine land) and outside the swampy area agriculture fields (Picture 7, Annex 3) with some isolated oak trees or crops of other species. Added to the vegetation are the ruderal and arvense flora and broad use cultivated trees .

Caducifolio Rain Forest (Picture 9, Annex 3)

In México, this community is part of a set of forests which ecologic requirements that make them disseminate in warm-dry climate regions. They are basically formed by succulent plants (fleshy, water retainers), whether at the root, stem or leaves. Almost 100% of the treelike species loose their leaves during the dry season (5 to 8 months). This type of vegetation grows on the hills and consequently shallow soil with good drainage. From the altitude standpoint, it is located between 0 and 1900 m but more frequently under the 1500 mosl.

5 The discrepancy with what is mentioned in Table IV.2 can be explained as follows: the subtropical scrubland reported in the National Forestry Inventory corresponds to a secondary succession of caducifolios rain forest while the oak trees correspond to a caducifolio rain forest, with presence really in a few oak species. The differences are less marked if you take into account that the forestry inventory is strongly based on the data obtained by remote perception and macro scale, while for this project we collect the information *in situ*. We recommend you check Annex 3, the photographic report of the manifestation.

Its structure is thick and heterogeneous and presents three well defined strata, the arborous, shrub-like and the herbaceous. The annual climbing plants also participate here although they are not abundant, the lianas and some epiphytes that grow on the trees, specially in the most protected sites that retain more humidity. Another feature of this kind of vegetation is the low height of its trees (generally between 5 and 10 meters height), which often times are broader than tall and their trunks and branches are tortuous.

The arborous stratum is represented at SAR by the following species:

Acacia pennatula (Steel Acacia, Sweet Acacia *racemosa, Bursera cuneata* (Copal tree) *Casimiroa edulis* (Mexican apple), *Cedrela dugesii* (Royal Cedar), *Celtis caudata* (Forestiera, Palo prieto), *Eysenhardtia platycarpa* (Kidneywood), *Eysenhardtia polystachya* (Kidneywood), *Ipomoea murucoides* (Morning-glory tree), *Lysiloma acapulcensis* (Borderpod Acacia Tree), *Opuntia atropes* (Prickly pear), *Opuntia fuliginosa* (Nopal cactus), *Opuntia icterica* (Cactus family "Nopal negrito"), *Pistachia Mexicana (Mexican Pistachio), Quercus deserticola* (Oak), *Stenocereus dumortieri* (Organ cactus).

Rzedowski y Calderón (1987) also quote, for a well surveyed location found 5 km to the west of Villa Jiménez, the following arborous species:

Aralia humilis, Bursera fagaroides (Copal tree), *Bursera palmeri* (Copal tree), *Erytrina breviflora* (Coral bean tree), *Erythina coralloides* (Color bean tree), *Forestiera tomentosa* (Desert hackberry), *Heliocarpus therebintinaceus* (Majagua bush), *Lysiloma microphyllum* (Tepemezquite), *Vernonia paniculata, Viguiera quinqueradiata* (Honeycomb rose).

In the shrub-like stratum we find the following species:

Acacia farnesiana (Sweet Acacia), *Asterohyptis stellulata, Calliandra sp., Hyptis albida* (Hierba del ahito), *Hyptis mutabilis, Lagascea helianthifolia, Lantana camara* (Calico bush), *Mimosa albida* (ca-claw mimosa), *Montanoa bipinnatifida* (Picture 14-a, Annex 3), *Montanoa leucantha* (Tree daisy), *Senecio salignus* (Goldenrod senecio), *Tecoma stans* (Wooly senna), *Triumfetta galeottiana, Verbesina sphaerocephala* ((family) aster).

In the herbaceous stratum, we have:

Adiantum poiretii (Fern), *Castilleja sp.* (Picture 12-b, Annex 3), *Gnaphalium chartaceum* (Cudweed), *Gnaphalium sp.* (Cudweed), *Loeselia mexicana* (Hummingbird flower), *Lopezia racemosa* (Storksbill), *Mitracarpus hirtus, Muhlenbergia rigida* (Popote), *Salvia polystachya* (Picture 13-a, Annex 3), *Salvia purpurea* (Picture 13-b, Annex 3), *Sporobulus pyramidatus, Stevia ovata, Tagetes lucida* (Chrysanthemum), *Zinnia peruviana.* The lianas or vines are represented by *Cissus sicyioides* (Sweet-and-vile vine), *Serjania racemosa.* A registered epiphyte of this kind of vegetation is *Tillandsia recurvata* (Ball moss).

On the external part of the La Hoya la Alberca (Alberca de Los Espinos) crater, we found the Caducifolio Rain Forest disturbed on the lower part of the hill and the same type of vegetation on the high part, but only with much smaller disturbance. The arborous species are:

Acacia pennatula (Steel Acacia, Sweet Acacia *racemosa*), *Bursera cuneata* (Copal), *Eysenhardtia polystachya* (Kidneywood), *Ipomoea murucoides* (Morning-glory tree), *Opuntia atropes* (prickly pear), *O. fuliginosa* (Nopal cactus), *O. icterica* (Cactus family "Nopal negrito"), *Pistachia mexicana* (Mexican pistachio), *Quercus deserticola* (Oak).

And of the shrub-like species: *Acacia farnesiana* (Sweet Acacia *racemosa*), *Lantana camara* (Calico bush), *Verbesina sphaerocephala* ((family) aster).

The caducifolio rain forest (Btc) is severely disturbed and open by the settlement of pasture fields, coamiles and the historical selective felling. A sample of this disturbance is the current dominance of the Morning-glory tree (*Ipomoea murucoides*), a secondary species. Even the species mentioned found in the La Hoya crater amongst which there are some primary species such as *Bursera cuneata, Pistachia mexicana and Quercus deserticola are found in the highest part and not on the skirts of the hill were the contour begins.*

Bosque de Galería (Pictures 8, 10, 40 ,46 and 48, Annex 3)

This is the name for the arborous communities available along the veins and river currents and permanent or semi-permanent streams. Their structure is normally heterogeneous and specific to the region and to the climate and topography.

At SAR, the Bosque de Galería is basically formed by the *Fraxinus uhdei tree* (ash tree, picture 38-a and 42, Annex 3) and *Salix bonplandiana* (Willow). In addition we also find *Taxodium mucronatum elements* (Mexican bald cypress, picture 41) at the 26th km of the project, although not close to the border.

The main shrub-like species of this kind of vegetation are: *Baccharis heterophyla* (Golden rod senecio, broom jute), *Baccharis salicifolia* (Golden rod senecio), *Lasianthaea macrocephala.* The reed, *Arundo donax*, forms populations that are also associated to the Bosque de Galería (Picture 48).

An herbal experience abundantly found in the areas where the gallery forest prevails is the orchid of the *Stenorrhynchos aurantiacus species*, that frequently mixes in non harvested open areas, with several weeds, between grass and herbs of the Compositae family.

The lianas or vines are represented in this forest by: *Vitis tiliifolia* (Wild grape), *Rhus radicans* (evergreen Zumac or poison ivy). An epiphyte species of the gallery forest, is *Tillandsia recurvata* (Ball moss). In addition, we register the *Psittacanthus calyculatus* (Mexican mistletoe), a parasite plant on the crown of some Willow trees:

Although you can find this type of vegetation naturally in the Laguna de Zacapu (external to the SAR), the Gallery Forest mentioned is the most outstanding community in the area of rivers, streams and irrigation channels distributed in the basin between Villa Jiménez, Huandacuca, El Fresno de la Reforma, La Piedad Chiquita and Panindícuaro. This vegetal formation is abundant and has an optimum development in the marginal irrigation channels pf the harvesting fields.

In this zone of the Gallery Forest (of *Fraxinus* y *Salix*) and the Caducifolio Rain Forest form a big Ecotone. The overlapping of both communities is so big and the extension were you can find it, that it is impractical to try to discriminate in the area both vegetal formations. This phenomenon has been fostered by the historical expansion of the distribution of the Gallery Forest throughout the channels and irrigations channels that cross hills and crop land, where the Ash trees and the Willows have disseminated outside the river and stream basins

Aquatic Vegetation (Picture 8, Annex 3)

The aquatic and sub aquatic vegetation is formed by several communities of plants linked to the water bodies or to soil more or less permanently saturated with water. Frequently they are disseminated, not well defined and they occupy small surfaces.

Its type depends upon the conjunction of several environmental factors such as the amount of water, temperature, luminosity. pH, purity, concentration of oxygen. Current speed, transparency and bed (clayish, sandy or rocky). At SAR they are close to water bodies in small areas that can not be cartographed at 1:50,000 scale (Annex 2).

The species registered are: *Canna indica* (Arrow root), *Eicchornia crassipes* (Lily, exzotic species from Brazil), *Hydrocotile umbellata, Polygonum mexicanum* (Chilillo), *Rorippa* sp. (Watercress), *Sagittaria latifolia, Typha domingensis* (Marsh edge).

Ruderal and Arvense Flora Communities

In accordance with Rzedowki (1978) and Guerrero-Nuño and López-Coronado (2004), the ruderal flora is the one that is formed by plants or wild vegetal communities characteristic of the neighboring areas to human habitats, at the side of roads and railroads, garbage dumps, uncultivated places and similar habitats. And the arvense plants are those that invade agricultural crops, gardens and flower pots.

The ruderal and Arvense flora communities found in SAR may be formed in a general manner by the following species: (including shrubs and herbs):

Aldama dentata, Amaranthus hybridus ((family) aster, Amarant), *Bidens odorata* (calendula-bur), *Buddleja sessilifora* (Dock sorrel), *Cosmos bipinnatus* (Purple cosmos) (Picture 14-b, Annex 3), *Cynodon dactylon* (Bermuda grass, Tobosa grass), *Dyssodia porophyllum var. cancelata* (Tree Tobacco),*Galinsoga parviflora, Gomphrena decumbens* (Globe amaranth), *Hyptis mutabilis, Leonotis nepetaefolia* (Castillitos, an exotic African species), *Mirabilis Xalapa* (Four o'clock), *Nicotiana glauca* ((type of) Basil, South American exitor species), *Pennisetum purpureum* (Elephant grass), *Phytolacca icosandra* (Conguerán), *Rhynchelytrum repens* (pinkish grass, Honey grass), *Ricinus communis* (Castor bean, Exotic species of African origin) *Salvia tiliifolia, Senecio salignus* (Goldenrod Senecio), *Sicyos microphyllus* ((family) squash), *Sonchus oleraceus* (Cerraja), *Tagetes lunulata* (Marigold) (Picture 12-a, Annex 3), *Tithonia tubaeformis* (Acahute), *Verbena litoralis, Verbesina sphaerocephala* ((family) aster), *Zinnia peruviana*.

The recording of an individual of the *Prosopis laevigata* (Mezquite tree) species and of two individuals from the *Pithecellobium dulce* (Ape´s earring) totally isolated between Zacapu and

Villa Jiménez tell us the probable existence in the past of Thorny Forests, now entirely dismounted and which previously should have occupied at least in part the alluvium valleys used for agricultural purposes nowadays.

Harvested Trees

Some species of cultivated trees are part of the landscape at SAR, because they are integrated to the fields in substitution or the original species, and some of them, due to their rapid growth or because they have other desirable characteristics. The ones that are more cultivated are two tree species that in general terms are used aligned to the fences as curtains, windbreakers or for shadow purposes and they are both originally from Australia: Casuarina, *Casuarina cunninghamiana*, and the Eucapiltus or Giant, *Eucalyptus camaldulensis*. Another species, but this is a Mexican species, used for the same purpose is the White Cedar tree (*Cupressus lusitanica*). In the contour of the project, we also find in km 16 a series of Custard Apple (Chirimoya the Spanish for *Annona cherimola*), grown in a fence. This species is originally from South America.

Uses given to vegetal species at SAR

Table IV.10. Uses given to vegetal species at SAR.

Species	Common Name	Use	Part
Acacia pennatula	Cat-Claw Acacia	**Fire Wood**	**Wood**
Adiantum poiretii	Fern	**Ornate**	**All the plant**
Amaranthus hybridus	Pigweed	Food	foliage in plantula
Baccharis salicifolia	Rock Rose	Like soap due to its saponine when rubbing it against the clothes	Leaf
Bidens odorata	Calendura-bur	Medicine	Flower (cabezuela)
Bursera cuneata	Copal tree	Incense	Resin
Bursera palmeri	Copal tree	Incense	Resin
Casimiroa edulis	Mexican apple	Food	Fruit
Cosmos bipinnatus	Purple sunflower	Ornament	Flower. It sells in bunches in small scale at the markets
Eysenhardtia polystachya	Kidneywood	Medicine and several uses of the trunk and branches	Wood, trunk and branches
Hyptis albida	Sage	Hierba del haito	Medicine leaf
Mirabilis jalapa	Maravilla	Ornamental Marvel	Has been tamed and is grown in gardens
Montanoa tomentosa	Tree daisy	Entire plant For abortion	Leaves and flowers
Montanoa tomentosa	Tree daisy	Several uses of the straight and flexible branches	Branches
Muhlenbergia rigida	Popote	Manufacture of brooms	Stems (culmos)
Opuntia atropes	Nopal tree	Food	Stalk (cladolio)
Opuntia fuliginosa	Nopal tree	Food	Stalk (cladolio)
Tagetes lucida	Chrysanthenum	Ornamental, Insectice and medicine	Flower
Tecoma stands	Woolly Senna or Yellow Elder	Medicine	Leaf
Typha domingensis	(Type of) sedge	To make chair seats and domestic devices	Leaf

Commercially significant species

There are some species considered here such as the Kidneywood (*Eysenhardtia polystachya*), Species largely sold in the herb stores of the large cities in México.
In the same context is the Woolly Senna (*Tecoma stans*) and to some decree the Cactus Tree, *Opuntia fuliginosa*, that is also sold in the flee markets or street markets.

Vegetal specifies included in the NOM-059-SEMARNAT-2001

It is the sole vegetal species that has been recorded in this study amongst the species under this norm, *Cedrela dugesii*, and it is a cedar species that is under Special Protection, Several trees of this species, 4 m high on the average are found on Km 14+714 of the location (Coordinates UTM, 13Q 211427, 2206051).

Status of conservation of the natural vegetation at SAR

The non agricultural part of SAR is basically formed by two dominant ecological systems: caducifolio (Btc) tropical forest and the Gallery Forest6. In accordance with the conditions described for SAR's vegetation, there is a deep disturbance of the original Btc vegetation, because at present the dominant trees are the Morning-glory trees (*Ipomoea murucoides*). The *Eysenhardtia and Opuntia* species are also secondary species that happen with selective clearing of trees in the Rain Forest. If the Galley Forest, the arborous stratum is in excellent conditions due to the abundance of rivers and streams, channels and irrigation channels that have even fostered the expansion of the natural distribution of this kind of vegetation that is normally associated to the natural water bodies.

The ecotonic mix of the Gallery Forest and the Caducifolio Rain Forest makes us see two different conditions at the same site, an emerging arborous status of Ash trees and Willow trees and a lower stratum of "Morning glory trees, Kidneywood and Cactus Trees, as a result of the selective clearing of the Caducifolio Rain Forest in addition to a closed and almost impenetrable grove promoted by the disturbance of the hillside areas. On the other hand the agriecosysen that represents the combination of the Gallery Forest and of the farming land represent a stable ecosystem status because the trees are respected and they represent significant shelter and biological corridor areas,

Vegetation structure at SAR

In order to know the vegetation structure at SAR an analysis was made related to the horizontal space parameters of the higher stratum of the Caducifolio rain forest. This type of vegetation was the only one taken into consideration because it is the only one evenly distributed. Thus 15 sampling sites were made between the coordinates UTM: 211126, 2204281 and 211289, 2205659. Six samples in total were recorded, and the mean distance between them is 10.77 m and the total density of trees/ha is 86.21.

In each site the sampling method known as "method of the quadrants centered in a space" was applied, and through it the composition of the species and the space distribution of individuals is known, as well as density per species and total per area unit, and thus the dominance can also be calculated, and in turn estimate the volumes by forestry cubic metering method. The summary of the samples is shown in Table IV.11.

Table IV.11. Summary of the samplings made.

Species	Abound (no.)	Presence (sites)	Height (m)	A.B. (DAP cm)	Do-A	F-A	F-r	De-r	Do-R	V.I.
Acacia pennatula	8	6	2.0	11.87	94.9	40	20.71	13.33	4.71	38.75
Eysenhardtia plystachya	3	3	1.86	6	18	20	10.35	5	0.89	16.24
Ipomoea	44	5	4.72	40.14	1766	100	51.78	73.33	87.68	218.79
Opuntia atropes	2	2	3.2	35	70	13.3	6.88	3.33	3.47	13.68
O.fuliginosa	1	1	2.9	25	25	6.6	3.41	1.66	1.24	6.31
O.icterica	1	1	3.5	36	36	6.6	3.41	1.66	1.78	6.85
Tecoma stans	1	1	1.83	4.5	4.5	6.6	3.41	1.66	0.22	5.29
Totals	60				2014	193.1	100.0	100.0	100.0	100.0

In the sampling made, 7 species were registered as forming the current community of the Caducifolio Ran forest in the area between La Hoya La Alberca and Villa Jiménez on the Zipimeo path. Based on the results, this part of SAR is extremely disturbed, since none of the species found there now are considered to be a primary species of this type of vegetation, conversely, these are secondary species that happened after the selective clearing took place. If you compare this composition of species with those of the highlands at La Hoya La Alberca, you will understand the difference between a better preserved habitat and another one subject to agricultural and livestock breeding management or to selective extraction.

Individuals of the different species maintain a medium distance of 10.77 which for the standards of a caducifolio rain forest is considered to be a very open community. However, the appearance of the landscape here is a major cover. This is the result of abundant secondary bushes that cover the spaces between the individual arboreous. The distance between individuals allows an absolute average or 86.21 individuals per Ha. Averaging the date of the sites surveyed it was determined that the species with more relative density as *Ipomoea murucoides* (morning-glory tree), which besides being the most frequently found is the most dominant, and therefore it has the highest level of importance. This means that it is the denser species, with better distribution and that it domains with its biomass the other species. This and other Ipomoea arboreous species are the typical ones as dominant species in disturbed caducifolios rain forests. Next in importance is the cat-claw acacia, *Acacia pennatula* and then the kidneywood, *Eysenhardtia polystachya*, both equally indicators of disturbance. The value of importance is then the sum of the relative frequency, the relative density and the relative dominance. This value means a bigger number of individuals (high density) which refers to a good adaptation strategy, asides from higher frequency which denotes the uniform distributed reproduction, while in dominance, derived from the heftiness or biomass of the species means a good utilization of the nutrients and also of the space, together with good ecophysiological efficiency, stating in a dominance on the species of lesser importance and value, namely, that the species which higher importance and value work as controlling species of the ecosystem, those that are found subject to other vegetal species. In a broader sense, they are the most directly responsible for vegetal formation (type of vegetation) or community.

Finally in Table IV.12 you can see the use of soil or vegetation in the stretches that will affect the project.

Table IV.12. Description of the vegetation on the site and its right of way.

Section	Vegetation
Km 11+600 – 11+850	Secondary vegetation of the caducifolio rain forest with isolated trees at the foot of the hill of the crater La Hoya (La Alberca or La Alberca de los Espinos).
Km 11+850 – 12+400	Material Bank and some secondary trees isolated from the caducifolio rain forest plus shrub-like and secondary herbal vegetation
Km 12+400 – 12+500	Farming parcel
Km 12+500 – 12+560	Living quarters with small orchard and wind break curtain of white Cedar (*Cupressus lusitanica*) plus Ash Tree and planted Eucalyptus.
Km 12+560 – 12+710	Caducifolio rain forest disturbed with dominance of *Ipomoea Murucoides*
Km 12+710 – 14+600	Pasture field with secondary vegetation of the caducifolio rain forest with *Ipomoea murucoides* as dominant. In the stretch from Km 13+870 – 13+985 it limits to the west with irrigation agricultural fields
Km 14+600 – 16+900	Big ecotone between gallery forests of *Fraxinus* and *Salix associated to* channels and irrigation channels, with secondary communities of the caducifolio rain forest, with alternate parcels, coamiles being used or at rest and pasture land.
Km 16+900– 18+100	Farming fields, and streams and boundaries with gallery of forests of *Fraxinus and Salix* associated to channels of irrigation channels.
Km 18+100 – 18+300	Hill with rests of ecoton of the gallery forest and the caducifolio rain forest
Km 18+300 – 18+400	Parcel at rest.
Km 18+400 – 18+460	Gallery forest of *Fraxinus and Salix* at the river.
Km 18+460 – 18+876	Parcel with isolated trees
Km 18+876 – 19+600	Highway Villa Jiménez – Autopista México-Guadalajara, surrounded by farming fields and trees on the right of way.

FAUNA

A total of 60 vertebrate species were recorded for SAR: amphibious (4 species). Reptiles (6), birds (35) and mammals (13). Of course this is a partial study in accordance with the importance of the project, because a careful registration of species requires at least a one year cycle that includes fluctuations between seasons, local migrations, continental migrations and the time required for sufficient space sampling. The species were registered by direct observation or evidence of the trails (excretes, skeletons or vocalizations), or rather, by reference of persons who live in the area. The systematic list of species can be seen in the Annex of the Fauna Listings.

Amphibious

In this class a small frog of the *Hyla eximia* species was registered (Picture 15-c, Annex 3), species that can live associated to the channels and the very humid places while common frogs, *Rana montezumae*, requires of aquatic bodies to live. A toad, *Bufo compactilis*, is also part of this group. In the central part of SAR, the numerous water basis foster environmental humidity that favors the habitat of Salamanders or the dotted Salamandra (*Pseudoeurycea bell*) (Picture 15-b, Annex 3) that lives under trunks or stones. It likes to meander in the cortex of the fallen in decomposition trees, where there are abundant insect larvae (Álvarez and González, 1987).

All these amphibious are benefited by the existence of channels (Guzmán, 1990), and therefore the construction of channels or irrigation waterways allow the aquatic species to expand their distribution.

Reptiles

Of this zoo class the wall lizard, four snakes and a turtle were registered. The lizard registered lives normally associated to stonewalls that surround the paths or parcels or that are part of the corrals or open spaces. This lizard corresponds to the group of the so-called thorny lizards. It is the *Sceloporus grammicus* (Picture 16, Annex 3), species fed with insects.

The snakes registered are the one known as whip snake, *Masticophis flagellum*, the bull sake, *Pituophis deppei*, the indigo snake, *Drymarcon corais rubidus*, that practically live in all the SAR, where they basically hunt rodents and small birds. Another snake, is the vine snake, *Oxybelis aeneus*, typical of caducifolio rain forests, where normally it is found on the tress looking for preys.

The registration of the turtle corresponding to the mud turtle or River Turtle *Kinosternon integrum*, which habitat in SAR are the channels and feeding itself from carrion, aquatic insects and sometimes from vegetables (Álvarez and González, 1987).

Birds

As normally happens, there are plenty at SAR. There are three herons, *Casmerodius albus*, the heron with the golden feet, *Egretta thula*, and the cattle heron, *Bubulcus ibis*. The first two were found in the water bodies, channels and irrigation channels. The third one can be associated to water, but you can find it disseminated in the associated farming system with the fallow tasks, where it is fed with insects' larva taken out of the earth by the agricultural tractors, or they feed with insects repelled by the bovine cattle.

At SAR there are also large Auras (or turkey vultures) *Cathartes aura* (Picture 18, Annex 3). They were found on top of the Moctezuma bald cypress (Taxodium mucronatum) in the area close to Fresno de la Reforma.

Another representative group is the one of the fording birds such as the Killdeer *Charadrius vociferous*, species that is quite common between the furrows of the parcels with irrigation, although it is normally associated to lakes, dams and minor reservoirs.

Also part of SAR is a bird of prey such as the falcon cernícalo (Falco sparverius), that hangs on trees or towers and electric power cables looking for prey.

It is a bird of open places. The red tailed hawk (*Buteo jamaicensis*) is another bird of prey we saw flying over the crater of La Hoya la Alberca. This falco-inform normally is found on well-maintained places and it is not common to find it.

There was also a species of migrating hummingbird, which is typically associated to morning-glory tree (*Ipomoea murucoides*) of the caducifolio rain forest, from which flowers it takes the nectar; this is the humming bird colicanelo rufo (*Selasphorus rufus*) (Picture 17-b).

The common bobwhite, *Colinus virginianus* was also present eating the seeds that it finds on the farmland, however it is not abundant.

In the more humid areas of SAR at the foothill normally one can see several individuals of the *Fullica americana* species (Picture 19, Annex 3) normally called American Coot, a dark bluish gray color bird similar to ducks.

The *Piaya cayana* species (Brown cockoo) (Picture 17-a; Annex 3), *Catherpes mexicanus* (Troglodita saltapared), and *Polioptila caerulea* (Perlita piis), that were registered at SAR, and belong to the Btc. However, *C. mexicanus* is considered by López-Coronado and Guerrero-Nuño (2004) as a Rare Urban species, that frequents roofs and terrace roofs of the houses looking for ants, part of its diet.

The bird known as mockingbird (*Melanotis caerulescens*), found in places with perennial vegetation, was seen on the Gallery Forest. *Carduelis psaltria*, known as Jilguero dorsioscuro and *Carpodacus mexicanus*, the Mexican Sparrow or Carpodaco are found here, in open areas.

In the cotone of the Galley Forest and the Caducifolio Rain Forest, we registered the Warbler (*Wilsonia pusilla*).

Finally, in the most perturbed or urbanized places we find the Swallow in the most disturbed or urbanized places we find the barn swallow, *Hirundo rustica*, the domestic or agrarian sparrow (*Passer domesticus*) and *Quiscalus mexicanus*, the great tailed grackle.

Mammals

There are plenty of mammals at SAR, and most of them are in their shelter in the great ecotone of the gallery forest and the caducifolio rain forest, but it is evident that the large mammals prefer to live in the hill known as Brinco del Diablo, to the northeast of Villa Jiménez (SAR only includes its skirts), amongst them is the Coyote (*Canis latrans*), the lynx (*Lynx rufus*), and the fox (*Urocyon cinereoargenteus*). In the caducifolio rain forest is the ring-tailed cat *Bassariscus astutus* (omnivorous). Guerrero y Zalapa (2004), mention that the Fox (*U. cinereoargenteus*) is one of the animals that has adapted to the antropic influence in such a way that they are able to live in areas where the use of soil has been important, such as in the farming zones. Actually it is common that both the foxes as well as the coyotes are seen prowling close to the corrals looking for domestic preys, specially birds, and therefore the coyote has benefited by thes habits with the presence of urban nuclei or crops. The Tlacuache (*Didelphys virginiana*), has the same habits and therefore it is killed frequently because it is considered to be a thieve of chicken and eggs at the henhoiuses (Picture 20-a, Annex 3).

Other mammals registered such as the striped skunk (*Mephitis macroura*) are also species that more frequently are seen in environments where human activity is frequent, and they are seen crossing roads and frequently they are run over by cars. The lagomorfos can also be found at SAR. We registered two species of Rabbits, *Sylvilagus floridanus*, the East Rabbit and the *S. cunicularius*. Both are typical of wooded areas.

Within the medium size mammals also registered are the Coatí (*Nasua narica*) living in forests such as the caducifolio rain forest of the hill Brinco del Diablo, where they prefer places close to the water. In this sense the raccoon (*Procyon lotor*) another ne of the middle size animals registered, necessarily requires permanent waters to live, as is the case at SAR, although it takes refuge in more woody areas. It feeds on frogs and mollusks and small fruits and has to wet its food because it lacks saliva glands.

Of a similar size to those herein above is the Armadillo (*Dasypus novemcinctus*) (Picture 20-b, Annex 3), voracious consumer of insects that are abundant in the humid areas and it is easier to excavate there.

Amongst the mice registered at SAR, both *Liomys irroratus* (western spiny pocket mouse such as the dwarf mouse (*Baiomys musculus*) are species of the caducifolio rain forest . However, the second one also frequently visits the agricultural system (Chávez and Espinosa, 2005).

Table IV.13. Uses of fauna living at SAR

Species	Common Name	Use
Carpodacus mexicanus	Bird	Singing Bird
Mexican house finch	Bird	Singing Bird
Dasypus novemcinctus	Armadillo	Food
Didelphis virginiana	Tlacuache	Food
Ictalurus punctatus	Channel Catfish	Food
Rana montezumae	Black frog or	Common Food

Status of Conservation of Fauna and their habitat at SAR

In accordance with the registration of animal species at SAR most of the species are distributed in the corresponding environmental system that corresponds to the great ecotone between the gallery forest and the caducifolio rain forest , which includes part of the agro ecosystem of the Villa Jiménez zone. A large part of the fauna takes shelter at the hill Brinco del Diablo from where it moves downhill looking for food. Another set are the aquatic species both of amphibious and birds, that find an important habitat in the system described. Of the species registered, only a few show a net association with the disturbed environments. Although in SAR the caducifolio rain forest is significantly altered, the density of the secondary vegetation offsets the lack of a well-preserved arboreous stratum, and here the Gallery Forest also helps, as it is an ecological system with excellent conditions in the Villa Jimenez land. In general terms, the abundant vegetation offsets the impact caused by irrigation agriculture. Thus, the resilience of the system is far from being overwhelmed. The following species show balance in SAR's ecosystems due to its conserved habitat needs:

Amphibious: *Hyla eximia, Pseudoeurycea belli, Reptiles:, Drymarchon corais rubidus, Kinosternom integrum, Oxybelis aeneus, Pituophis deppei.*
Birds: *Buteo jamaicensis, Casmerodius albus, Colinus virginianus, Charadrius vociferous, Egretta thula, Falco sparverius, Fullica americana, Melanotis caerulescens, Piaya cayana, Poliptila caerulea, Selasphorus rufus.*

Mammals: *Baiomys musculus, Bassariscus astutus, Dasypus novemcinctus, Lynx rufus, Lyomis irroratus, Nasua narica, Procyon lotor, Sylvilagus floridanus, Sylvilalgus cunicularius.*

The other species, the more general ones, still include species that require good habitat conditions, although several of them have been adapted to human presence and activity. The previous lists of species show the general good conditions of SAR, which in part is fostered by the abundant supply of water and therefore vegetation.

Wild vertebrate species included in the NOM-059-SEMARNAT-2001

As part of SAR's fauna there are six species under some protection category by the Mexican Norms, which are included in Table IV.14. Besides that, four of the species found in SAR have some sub-specie included in that standard, notwithstanding that they are considered to be

present in SAR because what as found in the field could not be identified all the way down to the sub-specie or rather, that the distribution of the protected subspecies do not include SAR

Table IV.14. Species living in SAR included in NOM-059-Semarnat-2001.

Class	Common Name	Category
Amphibious		
Rana montezumae	Black or common frog	Special protection
Pseudoerycea belli	Salamander or Stained Salamandra	Threatened
Reptiles		
Sceloporus grammicus	Thorny lizard	Special Protection
Pituophis deppei	Bull snake	Threatened
Masticophis flagellum	Whip snake	Threatened
Kinosternon integrum	Mud river turtle	Special Protection

Birds

Note 1: This study registers the Common Bobwhite *Colinus virginianus*. However, it was not possible to determine a subspecies. The standard includes subspecies *ridgwayi* as being in danger of extinction, but not the entire species.

Note2: The standard quotes three northern subspecies of *Carpodacus mexicanus* under protection, the *clementis*, the *mcgregorii* and the *amplus*, but not the entire species.

Note 3: Although in this study it was not possible to determine the *Melanotis caerulescens* subspecies, the standard quotes the *longirostris* subspecies under special protection.

Mammals

Note 4: Two subspecies of *Bassariscus astutus*, the *insulicola* and the *saxicola,* both called northern ring tailed cat, both are listed as Threatened. However, in this study it was not possible to determine the sub-species.

IV.2.3 Landscape

SAR's landscape was studied based on three elements: scenic quality, fragility and connectivity. In general, the areas with original vegetation have more scenic quality that those sites which have lost it. In SAR the higher quality areas coincide with the highlands that correspond to the geomorphologic mountain unit, that have a caducifolio rain forest cover. These areas present more conservation and therefore high connectivity. Per se, these are large spots that can be considered to be a matrix, with little alteration. However, increase of the agricultural areas can endanger the stability of these spots.

On the other hand, there are hillside areas on the western side of SAR where there are bushes. Unlike the mountainous areas, these have less scenic quality due to human intervention. However, the connection between patches apparently has not been totally lost, more due to the small natural vegetation with secondary remaining that act as connectors so

that the fauna in the area is kept communicated. The fragility of this area is higher, mainly because it is close to the agricultural areas.

Regarding the foothill unit, it probably has the least scenic quality.

Mainly because the farming areas are located there and is the one that has secondary vegetation. The alteration of this system has generated that there is little natural vegetation remaining on the river banks (gallery vegetation). Therefore, the scenic quality is low, fragility is high and connectivity almost null. If the latter persists it is practically due to the gallery vegetation.

In conclusion, the landscape in SAR depends upon the area that you study. Although in general terms one can speak of two landscapes: the one maintained in the highland, and the degraded one in the lowlands. In the first one high scenic quality is predominant, landscape connectivity and a high degree of natural preservation. In the second place, the opposite happens, it is a typically anthropogenic landscape.

IV.2.4. Social Environment

SAR involves three municipalities of the Bajío region, the municipality of Jiménez integrates 50.1% (2783.81 Ha), Panindícuaro includes 43.7% (2428.28 Ha), and Zacapu has 6.2% (342.33 Ha) of SAR. A characterization of the social environment was made at municipal scale, since most of the socioeconomic indicators are presented at that level. However, there were exceptions, such as the contribution of the population to SAR, which could be analyzed at local level. In all cases, the bibliography information analysis was conceptualized with observations in the field.

DEMOGRAPHY

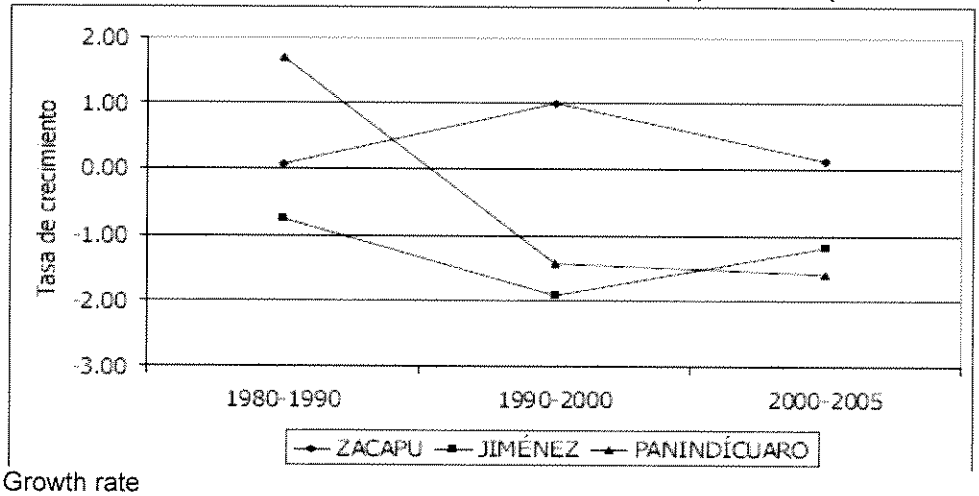
At SAR a total of 23 locations are registered and of those 4 are located in the municipality of Zacapu, 9 in Jiménez, 10 in Panindícuaro. The total population in SAR is 18,008 inhabitants, of which 53.5% lives in the municipality administration of Villa de Jiménez and Panindícuaro. In seven locations that have 1,500 and 500 inhabitants, 31.5% live in the village, while the remaining 15% is distributed in 14 smaller villages with less than 500 inhabitants (Table IV.15).

Table IV.15. Distribution of the population in SAR

Municipality	Location	Population
Panindícuaro	Panindícuaro	5538
Villa Jiménez	Villa Jiménez	4099
	7 locations with 500 to 1,500 inhabitants	5676
	14 Locations with less than 500 inhabitants	861
Total	23 locations	18008

Source: II Count of Population and Housing 2005. INEGI

Regarding the demographic trends of these municipalities in the last three decades, no growth or decrease is seen. Zacapu has, for the period 2000 to 2005 a 0.13% growth rate, while in Panindícuaro and Villa Jiménez growth is reported to be -1.59 and -1.19% respectively. These values can be considered a clear evidence of the migration flows weight that have positioned the state of Michoacán as one of the states that more population expels in the country.



Growth rate

Figure IV.6. Demographic evolution in the municipalities of Zacapu, Jiménez and Panindícuaro.

National Municipal Information System (SNIM) See. 7.0 INAFED. SEGOB, 2004

II Count of Population and Housing 2005. INEGI.

In general terms, in the SAR municipalities one can see that the portion of the population in working age, in the 15 to 64 year range, almost doubles the population of the population younger than 14 years. This is a typical situation for the state and the country and in part is attributed to the decrease in fertility levels and the generation replacement experienced I the country in later years. (CONAPO, 2004). The municipality of Jiménez has the largest number of older than 65-year persons and a smaller proportion of them are between 15 and 64 years, which suggest more intense immigration (Figure IV.7).

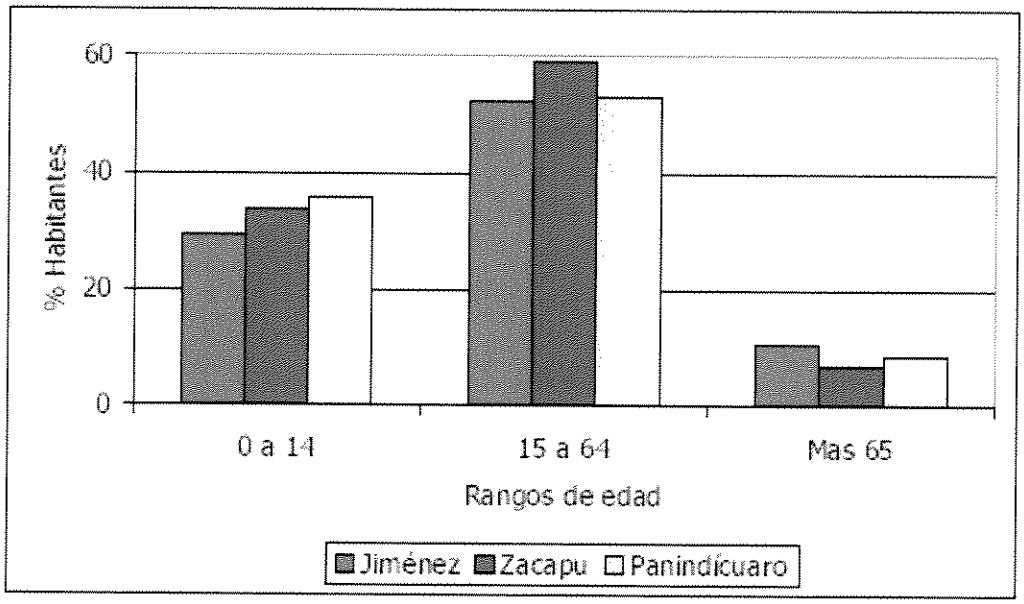


Figure IV.7. Population distribution per age group in the municipalities in the area being studied.

XII General Population and Housing Census 2000, INEGI.

In turn, the population density variation, in the period 1995 to 2005 (SEGOB, 2004), gives us a relative stagnation in the Zacapu municipality (went from 214.33 to 219.35 hab/Km2) and reduction of the Jiménez and Panindícuaro Municipalities (from 50.23 to 41.99 hab/Km2 and 72.76 to 61.94 hab/Km2 respectively), attributable to the displacement of its inhabitants to other municipalities, probably Morelia, Guadalajara or North America.

The Municipal administration and the main cities of the municipalities concentrate the population and the services. The population weight of the municipal administrations is significantly bigger in Zacapu, with 70% unlike the one in Jiménez, which is 30.7%, and

Panindícuaro with 30.8%. However, in SAR 53.5% of the population lives in the cities of Villa Jiménez and Panindícuaro. The project will not affect the demographic performance or the population density in SAR, but constitutes an improvement in security by bypassing traffic from the villages that are presently crossed by the existing highway. On the other hand, the lower vehicle traffic will allow crossing of inhabitants from one to the other side of the highway.

MARGINATION AND INDIGENOUS POPULATION

In accordance with the National Population and Housing Council, the municipality of Zacapu is of very low margination, and is one of the five municipalities less marginalized in the State, with regard to Jiménez and Panindícuaro, it shows medium degrees of margination, and occupy positions 72 and 48, respectively in the State of Michoacán (Table IV.16). The relative well being can be partly explained by the remittances migrants to the United States have send, and which are reflected in the improvement of the houses and services.

The indigenous population in the three municipalities is scarce, with values of less than 2% and predominantly speaking the Purhépecha language (Table IV.16). It should be mentioned that, due to the nature of the project, it is not feasible that a direct relationship between the activities as implied in the project and the conditions of the indigenous inhabitants.

Table IV.16. Degree of marginal status until 2000 and indigenous population by municipality in SAR

Variable	Municipality		
	Zacapu	**Jiménez**	**Panindícuaro**
Degree of Margination	Very low	Medium	Medium
Index	-1.28114	-0.51147	-0.25557
% Indigenous Population (indigenous language)	1.53	0.25	0.21
Languages	Purépecha and Nahuatl	Purépecha and Maya	Purépecha and Zapoteca

SNIM. See. 7.0 INAFED. Secretary of State, 2004.

SOCIAL DEVELOPMENT

Housing

In the three municipalities of SAR, there is a similar overcrowding with 4 inhabitants per house. However, the services provided seem to be very different, because while in Zacapu there is almost and 80% of houses with electricity and sewage, in Jiménez it is only 75% and 58% in Panindícuaro (Table IV.17). Jiménez and Panindícuaro present and important proportion of houses that have piped water systems normally in hoses (26%).

Table IV.17. Characteristics of the housing for SAR municipalities.

% of Housing Characteristics	Municipality		
	Zacapu	Jiménez	Panindícuaro
Houses with sewage and piped water	12.27	26.28	26.08
Houses with sewage and electricity	79.64	75.37	57.64
Houses without services	0.97	1.20	1.87
Overcrowding index (Inhab/house)	4	4	4

SNIM. See. 7.0 INAFED. Secretary of State, 2004.

Education

The municipality of Zacapu has a total of 132 schools, followed by Panindícuaro with 61. Nevertheless, in all cases this education infrastructure is enough for the population it serves. Regarding the degree of literacy, Zacapu has the highest proportion of literate population 91%. Zacapu is the only municipality that offers education options at medium higher level and work training centers and given its closeness with the other two municipalities, this is an alternative for the student population coming from them. (Table IV.18).

Table IV.18. Population that knows how to read and write; basic and middle education schools.

Variable	Municipality		
	Zacapu	Jiménez	Panindícuaro
% of literate persons	90.9	86.8	84.7
Grammar schools	56	23	26
Secondary schools	20	8	9
Total school	132	47	61

SNIM. See. 7.0 INAFED. Secretary of State, 2004.

Health

Regarding the health sector services, the municipality of Zacapu has the best health infrastructure installed with 13 units, two of them in the second level. In contrast, Jiménez and Panindícuaro only have basic care clinics. There are no third level or specialty hospitals in this area, and therefore this demand is covered with the medical services that Morelia and Zamora have and other foreign clinics such as those in Celaya, Guadalajara, located relatively close, and also private clinics.

Table IV.19. Medical units in service from the Public institutions of the health sector.

Medical Units	No. of Medical Units per Municipality		
	Zacapu	Jiménez	Panindícuaro
First level (Clinic)	11	5	7
Second level (Hospital)	2	0	0
Third level (Specialty Hospital)	0	0	0
Total	13	5	7

Annual Statistics of Michoacán. 2004. INEGI.

Accessibility

The municipalities in SAR have paved state like roads and also lined rural roads.

Table IV.20. Length in kilometers of the state road network per type of road

Type of Road	Specific Characteristics	Municipality Zacapu	Jiménez	Panindícuaro
State	Paved and lined	20.60	19	21.20
Rural Roads	Paved and lined	16.20	25	40.40
Total		75.10	44	61.60

Annual Statistics of Michoacán, 2005. INEGI

ECONOMIC DEVELOPMENT

The distribution of PEA per sectors allows the to differentiate two very different situations: a big development of the secondary and tertiary sector in Zacapu (31 and 55% of PEA in these sectors) and a more agricultural economy in Jiménez and Puruándiro (46 and 55% of PEA in the primary sector for these municipalities).

The background of this lies in the take off of Zacapu was promoted in past decades by irrigation district, and defined it as agricultural and livestock breeding development pole in the region. This generated a demand for transformation industries (processed food, industrial materials) and of services at large and trade of products such as shoes, dairy and equipment (Table IV.21).

Table IV.21. Distribution of the Economically active population by Sectors at SAR

PEA Percentage	Municipality		
	Zacapu	Jiménez	Panindícuaro
Primary Sector|	11.74	45.58	55.41
Secondary Sector	30.6	20.24	18.45
Tertiary Sector	54.63	31.20	21.87

SNIM. See. 7.0 INAFED. Secretary of State, 2004.

The water resource is relevant in the zone, due to its use for activities such as fishing, pisciculture and entertainment. The government as one of the state's development poles has promoted Zacapu. In the field of transformation, it has industries such as CELANESE Mexicana, NOVACEL, Promotora Zacapu, for the production of rubber and industrial plastics as well as factories of furniture, dairy products and sawmills. It also integrates trading of those products and therefore both branches incorporate 40% of pea. At this level of analysis the productive trend of PEA is confirmed in Jiménez and Panindícuaro towards the primary sector and in this context, they are entities that provide raw materials to be processed in Zacapu.

Analyzing per branch of activity, the relative economic tertiarization of Zacapu can be evidenced by three examples: the proportion of PEA in manufacturing industries in Zacapu is more than double of the one that corresponds to Jiménez or Panindícuaro, the trade proportion also, in financial services it is 20 times greater Zacapu than in Jiménez. In this manner, Zacapu is outstanding as the most economically self sufficient municipality, while Jiménez and Panindícuaro present growth trends in areas to be developed such as agricultural technification, use of water resources and ecotourism (SEPLADE, 2005).

Table IV.21a. PEA per branch of activity (XII Population and Housing Census 2000, INEGI).

PEA per activity	Municipality		
	Zacapu	Jiménez	Panindícuaro
Agriculture, livestock breeding, forestry use, fishing and hunting	11.74	45.58	55.41
Mining	0.19	0.19	0.02
Manufacturing Industries	20.07	7.96	8.85
Electricity and water	0.39	0.50	0.24
Construction	9.93	11.57	9.32
Trade	20.51	9.75	8.34
Transportation and Communications	4.25	2.55	2.21
Financial Services	0.40	0.02	0.22
Government activities	2.58	3.58	2.03
Entertainment and Cultural Services	0.70	0.39	0.42
Professional services	1.28	0.33	0.22
Hotel and Restaurant Services	3.48	1.76	1.63
Real Estate Services	0.23	0.05	0.04
Health and Social Assistance Services	3.57	1.06	0.67
PEA per activity	Zacapu	Jiménez	Panindícuaro
Education Services	7.64	5.60	1.52

SNIM. See. 7.0 INAFED. Secretary of State, 2004.

IV.4. Environmental Diagnostic

IV.4.1. Description of the general SAR functioning

The key factor to determine the original ecologic functioning is the geomorphologic unit, which together with the climate and edaphic type determines the vegetation. In its original condition, in the SAR the deciduous tropical forest (Btc) was abundant, but at present productive activities of the primary sector have had a highly important influence, through felling of trees (leveled) and cattle breeding (Figure IV.8).

Next, an analysis of the functioning of the geomorphologic units will be given relating climate, soils, vegetation and the influence of man.

In the mountain unit the surface lithology is made of extrusive igneous rocks which is an area of strong draining and soils with truncated-formation or young soils (by the constant loss of material). Because of the presence of faults and fractures on the igneous rock, these are recharging sites to the aquifer.

These units are the best conserved within the SAR, they sustain a Btc with predominance of original species, and thanks to this their poor and erodable soils are maintained in good condition, because the forest canopy prevents the soil from being lost and/or depleted. When erosion is present, there is an intensive loss of material (due to its being a unit with high energy due to its slopes) but also the contribution of organic matter and its mineralization is intense on account of the sub-humid climate type. The edaphic type is closely related to the position in the relief and vegetal cover; so, that the mountain front that receives the winds (SW) presents lithosol-type soils in the ledges and in the ravines where histosols remain humid; in the less strong slopes but which have an active chemical weathering (due to the arrival of draining and material) there are vertisols, while in the sites with less weathering the dominating type is the feozem. Cambiosols and andosols are observed in areas with vegetal coverage of more than 70 percent, in areas with a slope between 40 and up to 80 percent; these soils, when they lose the vegetal coverage, are rapidly converted into litosols since they are very erodable (Figure IV.8). This geomorphologic unit is fragile; it maintains original biogeochemical cycles and its conservation must be considered important. It is a recharge to the aquifer zone, so that it is very important to conserve the vegetal cover, because it retains the soil which is the rain water filter, in addition to acting as a sponge while water is being infiltrated; if the forest canopy were lost, run-off would increase and erosive ditches would be formed and infiltration would be reduced.

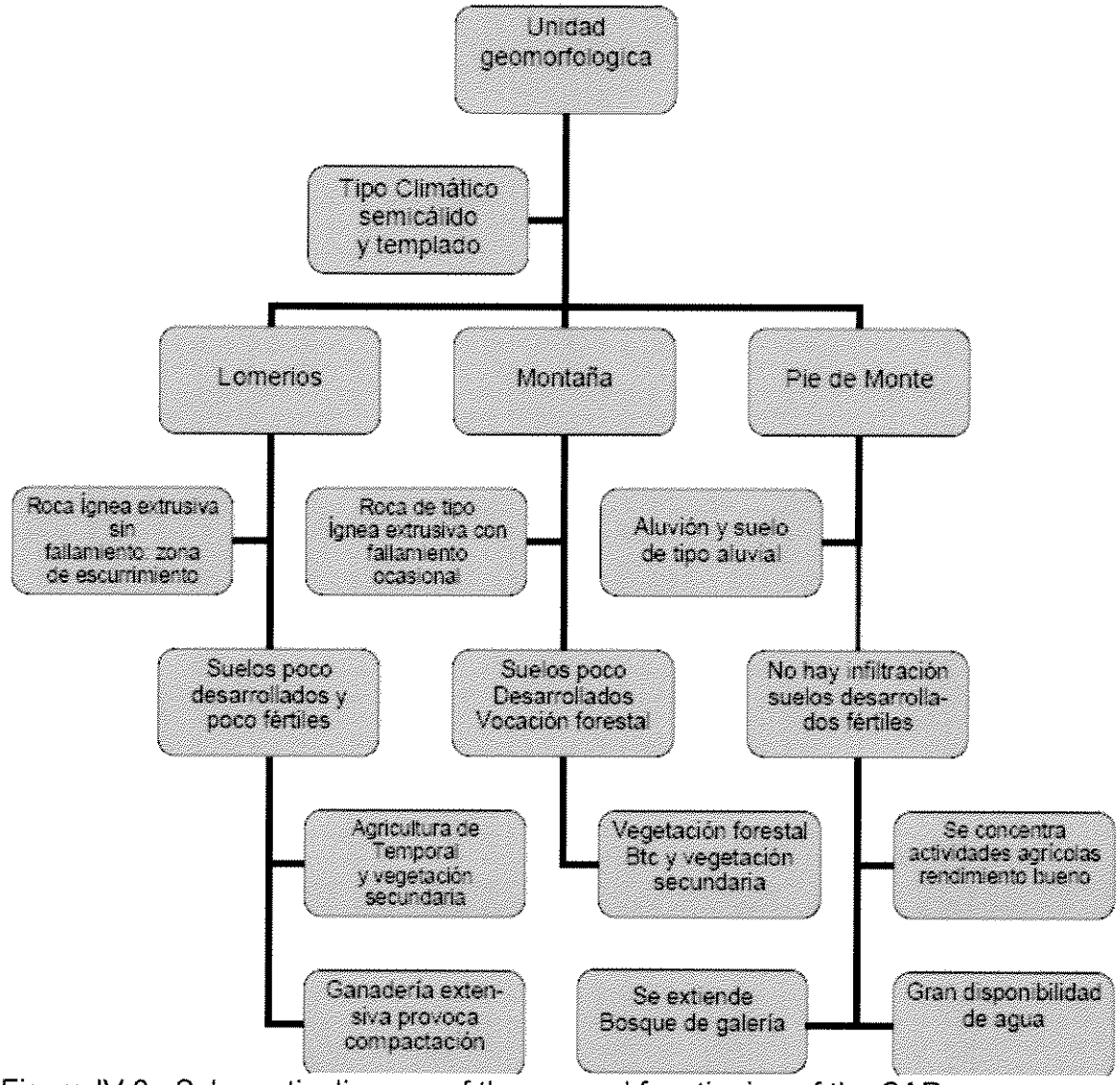


Figure IV.8. Schematic diagram of the general functioning of the SAR.

Organization chart legend, from top to bottom and from left to right:

- Geomorphologic unit
- Climate type semi-warm and temperate
- Hills
- Mountains
- Piedmont
- Extrusive igneous rock without faults: draining zone
- Extrusive igneous type rock with occasional faulting
- Alluvion and alluvial-type soil
- Poorly developed and low fertility soils
- Poorly developed soils and forest vocation
- There is no infiltration, developed, fertile soils
- Seasonal agriculture and secondary vegetation

- Forest vegetation, btc and secondary vegetation
- Concentrated in agricultural activities, good yield
- Extensive cattle breeding causes compaction
- Gallery forest is extended
- High availability of water

No considerable pressure caused by man was detected on the mountain unit, since agribusiness activities are oriented toward the foot of the mountain and hills. The mountain unit is a vegetal and animal species genomic reserve in a semi-altered by agriculture SAR landscape.

The hilly geomorphologic unit is a unit with strong drainage and low recharge to the aquifer (due to the lack of faults and fractures). This unit has partially lost its original vegetal cover because agricultural parcels have been opened and cattle breeding is extensive. The andosol and vertisol soils which lost their cover are eroded and currently interspersed with litosol-type soils. In the areas where the vegetal cover has been maintained, vertisol type soils can be observed and in lesser slopes the feozem can be observed. The geomorphologic unit is not very fragile because many of the disturbing factors have already occurred; in the areas with less slope, in feozem and vertisol type soils (alternating) agricultural and cattle breeding activities can be supported without degrading them. Still and all, in the andosol and vertisol type soils (the latter only in slopes of more than 50 percent), they must conserve the vegetal cover to prevent erosion. Secondary vegetation of the Btc is dominating in this unit. It is a habitat of general fauna species.

The geomorphologic piedmont unit is the one which receives the primary productive activities (agriculture and cattle breeding); the surface lithology is the alluvion and the dominating soil type is vertisol, and in a lower degree the feozem. The areas that have less slope in feozem and vertisol type soils can support (alternating) agricultural and cattle breeding activities without being degraded; in andosol and vertisol type soils however (the latter only in slopes of more than 50 percent) the vegetal cover must be conserved to prevent erosion. The secondary vegetation of the Btc is dominating in this unit. It is a habitat for general species.

The geomorphologic piedmont unit is the one which receives the primary productive activities (agriculture and cattle breeding); the surface lithology is the alluvion and the dominating edaphic type is vertisol and in lesser degree the feozem. Because of the contribution of the run-offs water from the mountain and hill unit, productive irrigation agriculture has developed subsisting without depleting the fertility of the soil. In the luvisol type soils and in one part of the vertisols (those found in the lower altitude parts of the SAR), the growth of gallery forest growth has been favored. In the past, it was only limited to the river banks. Species of the *Fraxinus, Salix and Taxodium* genus are successfully developed in the irrigation parcels and they form dense forests in the boundaries around the canals. The availability of water allows for the development of a bio-diverse underbrush, which is an important habitat for fauna species that have restricted habits, three included in the NOM-059-SEMARNAT-2001 Norm. This gallery forest patch-Btc has attained a balance with agriculture in the area. Irrigation makes it subsist and the gallery forest maintains moisture of the soil (preventing insolation) and constantly contributes with nutriments which are used by the cultivars. In addition, the owners of the parcels avoid damaging the gallery forest growing in the boundaries, because this way the restricted habit wild fauna prevents the proliferation of deleterious obnoxious fauna (a benefit for the farmers).

However, not all piedmonts have a shallow water table which favors a luvisol type soil; in the southern and northern parts of the SAR, there are also irrigation agricultural fields on soils with better draining (Feozem). These sites do not have the conditions to favor the growth of gallery forests. In their boundaries, introduced exotic tress grow, some left over from the Btc, and where only rivers or canals cross, there is a row of typical trees of a gallery forest. These sites have lost their original diversity and are considered as disturbance-resistant.

Table IV.22 Preliminary Diagnostic of SAR.

Unit	Soil type	Diagnostic
Mountain	Cambisol, litosol and andosol	Active laminar run-off zones; if with vegetal cover, the soil is conserved (andosol and cambiosol); if vegetal cover has been lost, a strong water erosion is observed in erosive ditches and litosol type soils. They constitute a surface run-off contribution area; in general, the original Btc cover is maintained and they depend on it for their maintenance
	Luvisol	Areas with strong bases flushing because they are recharge zones to the aquifer; they maintain their original vegetal cover, which at times is shown as sub-deciduous.
	Histosol	Located in relatively flat areas, it has a dense vegetal cover that maintains the moisture throughout the year; it has a mineralization of the active organic matter and it is the habitat of species with restricted habits.
	Vertisol and Feozem	These are areas with a moderate slope, receiving the contribution of higher-energy area material; feozem is fertile and with good drainage, so that at times it is seen sustaining seasonal agriculture in a forest matrix. Vertisol is less fertile, so that it normally sustains forest vegetation although extensive cattle growing is also present. On vertisol type soils, water erosion imprints can be observed.
Hills	Andosol and Litosol	These sites are the most disturbed within the mountain unit. Sustain part of the Btc remnants with secondary vegetation. It shows incipient erosion indications on the Andosol. It is an area with strong water erosion. When erosion is too serious, soils present are Litosols.
	Vertisol and Litosol	They are found in the areas with less slope, either presenting incipient erosion indications or not, but never severe. They sustain secondary vegetation and/or agricultural fields with good yields, especially in the Feozem.
	Histosol	These soils are normally oriented to the ravines, they may have Btc forest vegetation with secondary elements; they may also sustain gallery vegetation. Within this geomorphologic unit, these are the areas that have better conservation.
		They are found in areas with low slope, but with surface

	Vertisol and Litosol	run-off, which together with the loss of forest vegetation, cause medium water erosion. When this erosion is strong, soils present are the Litosols, and when weak the edaphic type is Vertisol.
Piedmont	Luvisol and vertisol	On this soil type there is an ecotone made up by gallery forest species and elements of the Btc. Distribution of the gallery forest and Btc elements was extended due to the incorporation of on-site irrigation which is favored by the surface alluvial lithology and the shallow water table. It is an ecotone that compensates the changes caused by the increase in insolation within the SAR as a result of the change in the use of land. In addition, it is the habitat of species with restricted habits, some of them included in the NOM-259-SEMARNAT-2001.
	Feozem and vertisol	All the Feozem in this geomorphologic unit is covered with agricultural and irrigation fields with good yields. The vertisol type soils are also agricultural, but when compared to the former, depleted parcels which are currently sustaining grasses for cattle are observed, as well as certain degradation shown by strong compaction and wide cracks during the dry season (expandable clays are collapsed).
	Histosol	These soils are only found in ravines filled with material or next to the river beds; they sustain gallery forests which in many cases act as boundaries of irrigated agricultural parcels.

IV.3.2 Diagnostic of the UNA's that make up the SAR

For the execution of the SAR environmental diagnostic the geomorphologic unit and the vegetal cover were used as criteria. From the map superposition of both criteria ten environmental units were determined (UNA's hereinafter), whose condition was evaluated by the use of indicators (Table IV.23 and Calculation Summary in Annex 5).

The properties of both criteria have been described in sections IV.2.1 and IV.2.2 and their condition is described through indicators of condition with values standardized between 0 (very disturbed) and 1 (highly conserved). The use of that scale is convenient for the matrix calculation in the geographic information system (the weight of the criterion will be subsequently multiplied by the status of the property and a summation of the values will be made for the layers. The determination of the state of conservation does not only describe the SAR systematically, but, in addition, it territorially guides the preventive measures and mitigation of adverse environmental impacts.

Criterion 1: Geomorphologic Unit

The indicators that we used to define the condition of every vegetal association were:

Value of importance of *Acacia pennatula, Eysenhardtia polystachya* and *Ipomoea murucoides*, species that indicate disturbance.

Fragmentation by type of vegetation; this index will be obtained from the analysis done in the landscape, taking into account the size of the patch and its connectivity by type of vegetation.

Coverage of the area measured in percentage, taking into account the base area
Vegetal community as a habitat for species of restricted habit fauna indicators of conservation: *Hyla eximia* and *Pseudoeurycea belli* (amphibians); *Drymarchon corals rubidus, Kinosternom integrum, Oxygelis aeneus and Pituophis deppei* (reptiles); *Buteo jamaicensis, Casmerodius albus, Colinus virginianus, Charadrius vociferous, Egretta thula, Falco sparverius, Fullica americana, Melanotis caerulescens, Piaya cayana, Poliptila caerulea* and *Selasphorus rufus* (fowl); as well as *Baiomys musculus, Bassariscus astutus, Dasypus novemcinctus, Lynx rufus, Lyomis irroratus, Nasua narica; Procyon lotor, Sylvilagus floridanus, Sylvilalgus cunicularius* (mammals).

The usefulness functions of each indicator were:

Value of importance: $F(x) = 1 - x/312$, where x = addition of the V.I. of the species mentioned
Fragmentation: $F(x) = x$, where x = connectivity of the patch with neighbor communities with forest vegetation
Cover: $F(x) = x/100$, where x is the percentage of cover of the basal area of the species of the vegetal community
Habitat of restricted-habit fauna: $F(x) = x/26$, where x is the number of species present from those listed before.

Table IV.23 Status of the properties of the vegetal cover

Indicator	Operation	Status
Seasonal agriculture	= (0.30 + 0.20 + 0.10 + 0.08)/4	0.17
Irrigation agriculture	= (0.45 + 0.80 + 0.40 + 0.31)/4	0.49
Deciduous tropical forest with VS	= (0.41 + 0.50 + 0.50 + 0.46)/4	0.47
Deciduous tropical forest	= (0.82 + 0.80 + 0.70 + 0.65)/4	0.74

Ecotone gallery forest-Btc	= (0.80 + 0.90 + 0.90 + 0.85)(4	0.86

After grading the condition of each property in both criteria, they were assigned a weight (W) according to the diagnostic value of each criterion taking into account the limitations of the information available (Table IV.24).

Table IV.24 Weight of the criteria selected.

Criterion	W	Explanation
Geomorphologic Unit	0.3	The geomorphologic unit would be an excellent indicator of status; in the case of the diagnostic evaluation of the SAR, it got a low weight because no data collected are available to have status indicators which are quantitatively scored. The only score given was qualitative. On the other hand, the geomorphologic unit allows us to define the dynamics that occur within it. The edaphic type Erodability, recharge to the aquifer, run-off index, among others.
Vegetal cover	0.7	Nevertheless with the exception of the soil type, this inference is only qualitative. In the case of the SAR, the vegetal cover is the best criterion to evaluate the status, since it has quantitative data available, in addition to the qualitative ones; recent data which allow us to know the status and functionability of the various areas that make up the SAR.

Four status categories were defined: highly disturbed, disturbed, conserved or much conserved. The diagnostic map is the result of adding with ponderation the layer of criterion 1 (geomorphology) and 2 (vegetal cover).

A highly disturbed UNA was considered when its raster cells got a value of less than 0.25.
A disturbed UNA was considered when its raster cells got a value between 0.251 and 0.5.
A conserved UNA was considered when its raster cells got a value between 0.501 and 0.75.
A much conserved UNA was considered when its raster cells got a value of more than 0.75.

The result is presented in Table IV.25. The largest extension corresponds to the disturbed status (88.6% of the area). The conserved one has 4.5 percent and 6.9 percent is considered as much conserved (Figure IV.9, Map 10, Annex 2). Results which are consistent with what is expressed throughout this study; there are no highly disturbed areas, although disturbed especially by the loss of original vegetal cover and/or erosion processes (although their strength has not been exceeded).

The SAR has conserved zones, which even if they have had impacts within, even if the use of land has been changed, their resilience is far from being exceeded and there may even be a UNA which is habitat of restricted habit species. The SAR still has areas with their

original nature (UNA 5) or with an uncommon biodiversity (UNA 4), such as the gallery forest that has been extended thanks to the incorporation of irrigation in fields that were leveled in the past.

Table IV.24 Area of the SAR according to the category of status.

Category	Area (Hectares)	Proportion (%)
Highly conserved	382.24	6.88
Conserved	249.42	4.49
Disturbed	4,922.77	88.63
Highly disturbed	0	0

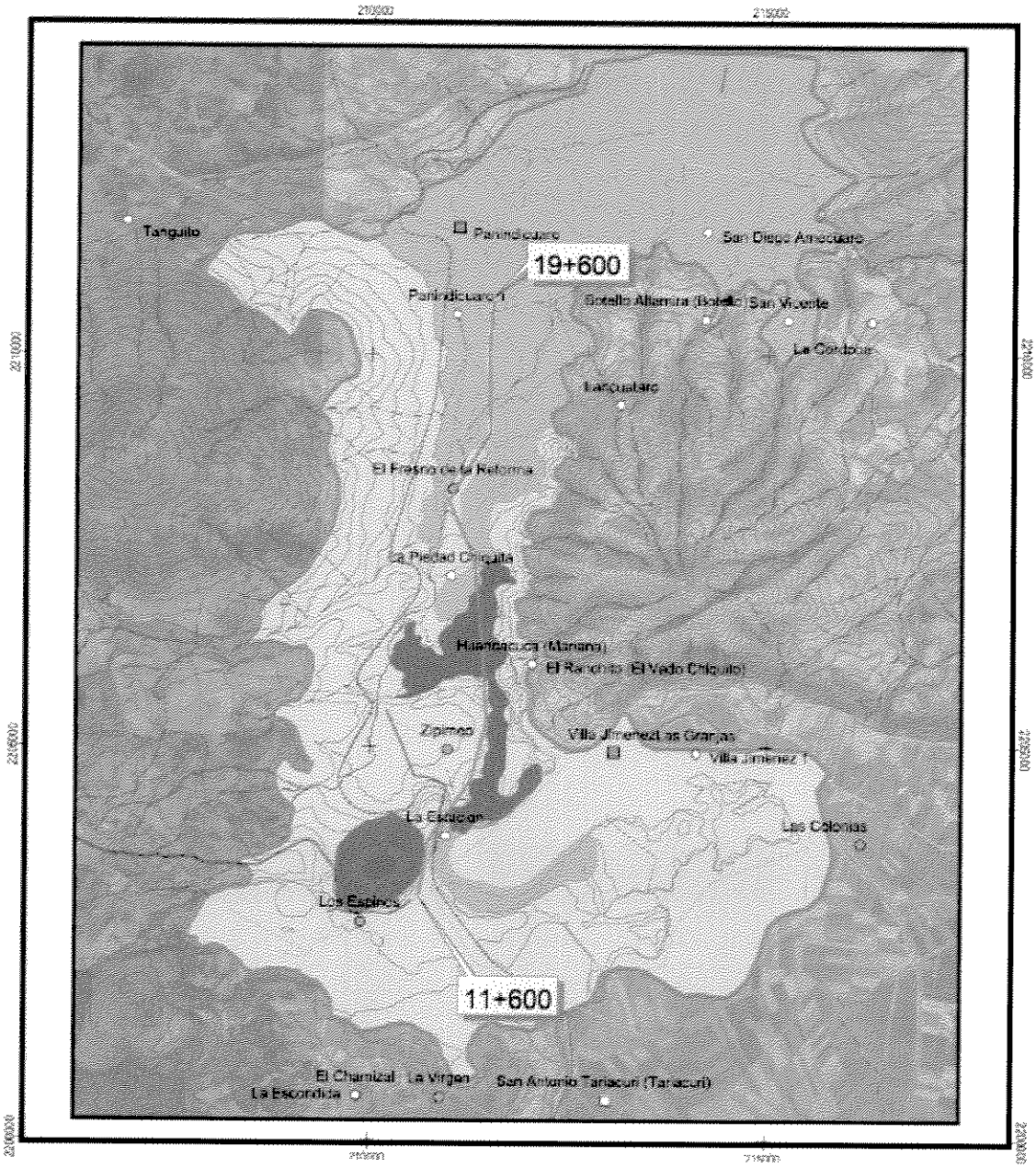


Figure IV.9 Regional environmental diagnostic

SYMBOLS:

Levels of conservation

-Highly conserved
-Conserved
- Disturbed

Cultural features

-Sites with 1 to 500 inhabitants
-Sites with 501 to 1500 inhabitants
-Sites with 1501 to 4000 inhabitants
-Sites with more than 4000 inhabitants

The outline of this project is distributed over 19.7 hectares of disturbed UNA's (UNA 3 and 8); 10.2 hectares in conserved UNA and 4.6 hectares in the UNA 4, considered as highly conserved (Table IV.25).

Table IV.25 Diagnostic by section of the project

Section	UNA	Diagnostic
Km 11+600 to 12+200	8	Disturbed
Km 12+200 to 14+550 and from 16+050 to 17+650	3	Disturbed
Km 14+550 to 15+750	4	Highly conserved
Km 15+750 to 16+050 and from 17+650 to 19+600	7	Conserved

IV.3.3 The regional environmental diagnostic

Table IV.26 includes for every environmental unit the status of conservation. This status is analyzed as well as the fragility or resistance it imposes, and considerations to be taken into account are established to analyze the environmental impacts (Chapter V), as well as to determine the need to guide the prevention and mitigation measures.

Table IV.26 Regional Environmental Diagnostic and considerations for the identification and evaluation of impacts.

UNA	Value	Status	Justification	Considerations
1	0.343	Disturbed and resistant	Vertisol and feozem type soils. The sites with feozem have good yields; they indicate incipient erosion only in the vertisol type soils, especially due to compaction as a result of extensive cattle-raising. The original flora species have been lost and it is the habitat of general and fauna-deleterious species. In the limits of the parcels next to the canals, typical gallery forest or secondary of the Btc species can be observed, so that the boundaries can be used by the fauna with the amplest mobility to move between patches which are better conserved.	Activities that might have the highest impact are going to be directed to this UNA. It is recommended that draft banks are placed. It is preferred that the trajectory of the road follows these lands. There are no important routes where fauna passes. Machinery
2	0.209	Highly disturbed and low fragility	This UNA has primarily vertisol and litosol type soil; it sustains parcels with seasonal agriculture that when quiescent are used for cattle. It has compaction and water erosion, from medium to severe, problems. It has completely lost its original biodiversity and	This UNA might sustain the project without relevant associated impacts, the only limitation being soil management. Draft banks might be placed, provided they are located at a distance of more than 1 km from the UNA 4. During the rainy season, the edge of the excavations must not be left for more than three

			it is used to divide patches which are better conserved. Dust storms are created in this site due to the air erosion of the bare soil in the dry season. In the boundary with the UNA 3 there is an edging line with gallery forest elements.	days between the excavation and the installation of the bases to avoid movement of materials.
3	0.419	Disturbed and fragile	This UNA has all the soil types described for the hills with the exception of the feozem, although vertisol is dominating; depending on the vegetal cover of the Btc with secondary vegetation, it avoids medium and severe erosion processes as presented in the UNA 2.	In case construction is required in this UNA, the time between leveling of the soil and installation of the bases must not exceed two weeks if it is during the rainy season. Although it would be better to have the activity during the dry season.
4	0.782	Highly conserved	This UNA is settled in the piedmont unit over the low permeability alluvion; the water table is shallow and agricultural irrigation has favored the growth of a gallery forest of primarily *Salix, Fraxinus* and *Taxodium* which is combined with Btc elements which in this case are taller and have perennial phenology. The erodability is low, in spite of the edaphic type, because of their location in relief. Important habitat for fauna with restricted habits.	To construct in these UNA's, leveling of the soil and all the building activities must be limited to the area between the zero lines. Machinery cannot be maneuvered and must not remain overnight. Tree felling must be With electrical saw and stumps must be removed with a maximum of two weeks before the front of the work begins by the construction of the bases. For leveling or any other activity, explosives or any machinery which generates noise of over 68 dB will be forbidden. Before felling the trees and leveling the soil, the area must

5	0.782	Highly conserved very fragile	This UNA is settled in the mountain unit and is made up by areas which still conserve the composition of the original Btc. There is a high run-off without erosion problems (because of the healthy vegetal cover); in the fault zone, there is water infiltration to the aquifer (it is under the over-exploited category). It is the habitat of species with restricted habits which were displaced to these sites when the use of the land of the piedmont and hills was changed.	be cleared with a machete and the rubbish must be manually removed, with the purpose of finding and transferring the fauna with domestic habits. The felling and leveling tasks must be carried out between October and February, from 9 a.m. to 6 p.m.
6	0.389	Disturbed Fragile	Skirts of the Brinco del Diablo mount, severe water erosion problems. At present it sustains pastureland induced with elements of the secondary vegetation of the Btc. The predominant soils are the vertisols, andosols and cambisols which when eroded they are like litosol. This is a run-off area and it has lost part of its infiltration to the aquifer capability.	This UNA may be used to construct, if and when it is compensated with reforesting works to the inside. It is an ideal site for remediation works that will include reforestation with native species (obtain genome from UNA5) and form terraces or berms to reduce the erosion.
7	0.523	Conserved Resistant	This UNA is located at the foot of the mountain over alluvial type soil; the dominating edaphic type is vertisol and feozem. Does not present erosion problems.	This is a disturbance resistant UNA; even so, it is recommended that no draft banks or constructions to support the work are placed in this site to prevent the loss of water of the boundaries of the

			Most of it sustains agricultural irrigation fields with good productivity. In its boundaries, gallery forest is developed with elements of the Btc. It is a habitat of general species, some deleterious and fowl and restricted-habit amphibians may also inhabit the gallery forest growing in the boundaries.	fields.
8	0.497	Disturbed Fragile	This UNA has differences inside, because it is located in the limits between the hills and the piedmont. There are parcels with seasonal agriculture, others that have been abandoned and which sustain induced pastureland or vegetation secondary of the Btc. In the ravines and next to the irrigation canals, gallery forest areas are observed. The soil shows medium erosion processes, although the fields with higher slope with extensive cattle raising it may be considered as severe. This is a habitat for general species and some with restricted habits.	The outline may be built, but it must be compensated with canal construction in the outside ends of the right of way and reforestation with Btc species as well as gallery forest species, to create a connective edge effect between UNA with a better state of conservation. Do not place waste banks in this UNA.
9	0.509	Conserved low fragility	This UNA was formed from seasonal agricultural fields that were abandoned. Currently there is approximately 12-year	Construction of the outline and attached works are allowed provided that the attached works are aimed at parcels with covers of less than 50 percent without regeneration of original

			Btc secondary vegetation growing and we consider that the limit of resistance has not been exceeded since juvenile of the original species have begun to be observed. No erosion problems are present and the fertility of the soil has been recovered. It is the habitat of general species and a few (two reptiles) of restricted habit species. Because of its cover, it works as a biological corridor between better conserved UNA's for the species that have an extended movement.	species; and restore after removing the attached works. Construct fauna passages in case the outline crosses this UNA. Avoid the incursion of machinery. Their movement must be limited to the right of way.
10	0.728	Conserved Fragile	This UNA is like number 8, located in the boundaries of the piedmont and the hills, without having a well defined boundary. In the high part, it has Btc with predominance of original species and in the low parts on the alluvion, gallery forest next to the irrigation canals. It has a medium erodability, although no indication of erosion was observed. It is the habitat of species with restricted habits which share the moist conditions of the gallery forest and the dry conditions of the Btc.	Construction of the outline is permitted, although the work and movement of machinery must be limited to the area between de zero lines. No attached work. No felling or leveling must be carried out between March and October. Check the underbrush before felling and leveling to relocate fauna.

IV.5 Development trends and deterioration of the SAR

As in many other environmental systems, the driver of change is the primary activities. Population growth of the municipalities that make up the SAR is practically zero or has a slight decrease (section IV.2.4). However, this trend is not related to economic growth. This is due to demographic factors, such as a reduction in the fertility rate and to economic factors, such as migration of people in search of sources of employment, which results in a higher number of adults than of children (CONAPO, 2004). This is a consequence of the job supply in the food, textile, medicine, machinery and equipment manufacturing industry in Zacapu and in the agribusinesses at semi-intensive and extensive levels given in Jimenez y Panindicuaro.

The economic base of the region is based on the industrial, agricultural and service industries primarily occurring in Zacapu. However, in the last decade important expulsion migration flows have taken place in the municipalities of Jimenez and Panindicuaro. In itself, the degree of migratory intensity is very high in Jimenez, high in Panindicuaro and medium in Zacapu. So that the first one reached 20 percent of the households with migrants to the United States in the last five-year administration, against 10 percent in the other two municipalities (CONAPO, 2000).

In the municipality of Zacapu, the development of industrial and commercial activities taps the agricultural and cattle-raising potential of the area. Because of its condition as a water supplier zone in the region, in the last few decades, strategies to drive economic growth have been implemented in Zacapu, favoring an increase in the number of zones for the establishment of industries, stores, urban developments and grazing areas (the latter is a lesser scales, but with a big effect on the system). When a higher economic gain is obtained with said activities, it is more feasible that the land is abandoned or that its use is changed from agriculture to urban zones. After analyzing the trend of the PEA by sector of activity during the 1995-2000 period of time, a clear inclination to the activities of the secondary (from 18.4 to 24.85 percent) and the tertiary (from 46.6 to 48.81 percent) sector is observed, specifically concerning the manufacturing industry, construction and trade. While for the primary activities there is a decrement: in 1995 34.9 percent is reported and for 2000 it goes down to 23.7 percent (CONAPO, 2000; INEGI, 2000). If these trends are maintained, stagnation in the agricultural area, and an increase in the urbanization is anticipated.

The natural environment of the SAR is considered a semi-disturbed system because or the large areas for seasonal and irrigation agriculture. It also presents patches with original vegetation which act as genomic reserve and gallery forest on parcels with irrigation, which increases the connectivity between conserved patches.

The intensive, semi-intensive agriculture and the pasturelands for the cattle use the hydro-agricultural infrastructure installed in the Zacapu irrigation district. The connectivity between the two basins, the Rio Angulo and the Rio Zacapu which make up the area of the SAR, acts as a conducting thread of the biological processes that give continuity to this system. It must be taken into account that, according to the evaluation done by the Secretariat of Urbanism and the Environment, the condition of the aquifers and flood zones of the Angulo basin is in balance, and Zacapu's is one of over-exploitation (SEPLADE, 2004).

The use of land processes of change will be the trigger to increase the fragmentation of the system. That is, the increase in the number of pasture grounds, of pastureland zones for cattle raising, of agricultural areas, the modification of beds and basins (for example, the irrigation canal in the vicinity of Jimenez) and the change in the use of land of agricultural zones to cattle breeding zones in the northern part of the SAR and the substitution of agricultural soils by urban infrastructure in the southern part.

Specifically, in the SAR, the construction of the project will not cause the increase in the fragmentation of the zone, because economic growth is the main factor of change of the system. Economic growth is translated in an eventual expansion of the urban zone (industry, services, human settlements) with the consequential fragmentation and degradation of the environmental system. In addition to this, the strategies of development proposed by the state administration, which include the intensification of the agricultural and cattle breeding activities (SEPLADE, 2004), would contribute to said processes of fragmentation in the short and medium term. However, it should be noted that actions to reforest, optimize the hydraulic systems and promote economic activities such as fishing, forestry and ecotourism (SEPLADE, 2004) are also proposed and which, in the medium term, might help mitigate the processes of deterioration and fragmentation.

Table IV.27 Summary of the conservation and/or deterioration trends of the SAR

Factor of change	Effect	Trend	Situation in 20 years
Urban infrastructure	Permanence of the adult population due to generation of sources of employment in the zone. Increase of the	The agro industrial activity is moving forward in specialization and the number of suppliers and transportation requirements is growing.	The trend of the urban infrastructure of the SAR is to grow, Zacapu acting as a strategic development pole (State Development Plan, 2002-2008). Population stagnation is a continued situation. North

	industrial and urban infrastructure. Urban areas currently cover 2.5 percent of the SAR.	Better equipment will be required in the population centers in the area. Strategies to drive the food, industrial materials (plastics) industries and a technification of agriculture and cattle breeding	American hardening moderates the migration flows and the amount of remittances. The urban area covers 4 percent of the SAR, with a growth oriented to Zacapu. Panindicuaro expands its extension. Zacapu is part of the industrial and commercial flows from El Bajio.
Semi-intensive and extensive agriculture and cattle raising.	Agriculture is distributed in UNA's 1, 2 and 7. Cattle raising is oriented to UNA's 2, 3 and 8. Loss of the natural vegetal cover due to extension of agricultural activities. Land is being reclaimed for gallery forest in agricultural parcels with irrigation. Soil compaction and loss of fertility only in UNA 3. Contamination by traditional fertilizers.	Intensification of agriculture in Jimenez and Panindicuaro to produce wheat, barley, chick pea, tomato and strawberry. It will be specialized in bovine and caprine dairy cattle. Infrastructure to support agriculture and cattle breeding. UNA 3 has a strong cattle breeding activity. Severe damages may be triggered and it would lose its nature. Reclaim land for gallery forest on UNA's 4, 8 and 10 by the incorporation of more agricultural fields to irrigation canals. This increases the connectivity of the	UNA 3 will present the same phenology as UNA 2 with severe erosion processes due to overgrazing. UNA 8 will be presented divided, 220 hectares will be incorporated to UNA 2 and the rest to the UNA 4 showing the same phenology as the Btc gallery forest ecotone. UNA 10 will tend to be more similar to UNA 4 with a predominance of gallery forest, so that the area with habitat for the restricted-habit species living in the gallery forest will be extended.

		SAR and compensates the fragmentation caused by the leveling and felling of seasonal agricultural fields. The resilience of the system has not been exceeded and, if the tertiary sector continues to grow, even in municipalities such as Villa Jimenez and Pandicuaro, we consider that there would be recuperation of the Btc and of the gallery with an availability of habitat for restricted-habit species. This trend was observed primarily in the UNA's 8 and 10.	
Mining (construction material banks)	Existence of petreous material banks in Zacapu and Jimenez High demand of water for the extraction process. The use of explosives negatively impacts species with distribution in the zone.	Standards for their rational use are being currently drafted to be included in the State's Ecological Equilibrium Law. Obvious progress of the secondary over the primary sector. Water supply services getting more expensive. Displacement of the zone's flora and fauna species. Removal of soil	Moderate impacts if the respective standards' guidelines are met. Increase in the activity in other sites of the region by the multiplying effect. Growth of the service industry (tertiary) that supports mining. Soils eroded and desertified. Depletion of water resources.

		will contribute to erosion processes.	
Transformation of water processes	Containment and disturbance of river beds. Erosion due to poor irrigation practices. Floods and over-flooding. Contamination and poor water quality for human use.	Over-exploitation of water tables will continue through the increase in hydro-agricultural infrastructure. Continued modification of the natural river beds interrupts biological and migration cycles of the endemic fauna and flora and favor species that live in gallery forests. Increase in water consumption and contamination for human settlements. Comprehensive basin management processes may reduce the deterioration processes.	Depletion of the water tables to irreversible levels. Displacement and reduction of population of species of the area, typical of dry environments. Exploitation of more distant from the region water sources. Future investment must make the hydro-agricultural infrastructure and urban and rural draining systems more efficient. If strategies to manage basins are applied in a timely fashion, the impacts of the activities carried out in the zone may be reduced.