Inventorying and Monitoring of Tropical Dry Forests Tree Diversity in Jalisco, Mexico Using a Geographical Information System

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Abstract—*Tropical dry forests in Mexico are an outstanding natural resource, due to the large surface area they cover. This ecosystem can be found from Baja California Norte to Chiapas on the eastern coast of the country. On the Gulf of Mexico side it grows from Tamaulipas to Yucatan. This is an ecosystem that is home to a wide diversity of plants, which include 114 tree species. These species lose their leaves for long periods of time during the year. This plant community prospers at altitudes varying from sea level up to 1700 meters, in a wide range of soil conditions. Studies regarding land attributes with full identification of tree species are scarce in Mexico. However, documenting the tree species composition of this ecosystem, and the environment conditions where it develops is good beginning to assess the diversity that can be found there. A geographical information system overlapping 4 layers of information was applied to define ecological units as a basic element that combines a series of homogeneous biotic and environmental factors that define specific growing conditions for several plant species. These ecological units were sampled to document tree species diversity in a land track of 4662 ha, known as "Arroyo Cuenca la Quebrada" located at Tomatlan, Jalisco. This paper will describe and discuss the methodology used for the study, the results obtained for three plant strata, the number of families found, the number of genera per family, and the number of species per family by Ecological Unit, and it will describe a follow up plan for monitoring this vegetation. This research was supported by Consejo Nacional de Ciencia y Tecnología (CONACYT), México, Project: 31808-B.*

Introduction

Mexico's biological diversity is one of its main natural resources for economic development, however, this biological potential has not been adequately assessed, and its use and conservation have not been addressed in a sustainable manner. Mexico is a very important country regarding its biodiversity use and conservation, because it is one of the twelve countries covering, as a group, between 60 to 70 percent of total planet's biodiversity; therefore, Mexico is considered a megadiverse country.

Although Mexico covers 1.3 percent of the planet's total area surface, it holds 10 percent of the world's biodiversity; it holds the first place in number of reptile species; fourth place in amphibious species; second place in mammals, eleventh place in birds, and fourth place in vascular plants. Similarly, Mexico has a great rate of endemism, with more than 800 endemic vertebrate species. Regarding the Mexican flora, its temperate forests are the most diverse on earth with 55 pine tree species and 138 oak species, with 85 percent of endemic pine tree species and 70 percent of endemic oak tree species.

Tropical dry forests in Mexico are an outstanding natural resource, due to the large surface area they cover. This ecosystem can be found from Baja California Norte to Chiapas on the eastern coast of the country. On the Gulf of Mexico side it grows from Tamaulipas to Yucatan. This is an ecosystem that is home to a wide diversity of plants, which include 114 tree species. These species lose their leaves for long periods of time during the year. This plant community prospers at altitudes varying from sea level up to 1700 meters, in a wide range of soil conditions. The most diverse dry forests in the world occur in southern Mexico and in the Bolivian lowlands (Bullock, Monney, and Medina, 1996; Gentry, 1993; and Parker and others, 1993).

Mexican inhabitants of tropical dry forest regions in Mexico benefit from this plant biodiversity using several species for medicinal purposes (*Crecentia alata*, *Guazuma ulmifolia*, *Tecoma stans*, and *Amphiterigium adstringens* among others), as a raw material for local construction, for firewood, fruit, raw material for handcrafts, honeybee production, raw material for fencing, forage, and religious purposes. However, not so much attention has been given to this magnificent natural resource, which currently faces the threat of the expansion of agricultural border for crops, grasslands and animal husbandry, overexploitation through illegal cutting, urban expansion, and the periodic occurrence of natural and human caused disturbances such as fires.

Despite this richness in natural resources, studies regarding land attributes with full identification of tree species for this ecosystem are scarce in Mexico. By this reason the general objective of this study was to develop a work methodology for the application of a geographical information system for a track of land located at "*Arroyo Cuenca la Quebrada*," Tomatlan, Jalisco. The specific objectives were a) To determine tree species composition of this ecosystem, b) To determine ecological units that define specific growing conditions for several plant species, and the number of families, the number of genera per family, and the number of species per family found, and c) To propose a follow up plan for monitoring this vegetation.

Review of Literature

Tropical Sub-deciduous Forests

According to Lamprecht (1986) these are dense forests with tall trees, deciduous in the dry season, which lasts from two to 7 months. These are transitional forests between tropical rain forests and tropical dry forests, by this reason they are highly variable in species composition, structure, physiognomy, and phenology. Their distribution occurs in Africa in regions at the mid equatorial rain forests, mostly at the south and east; in Asia in Hindustan and Indochina; Latin America, in the Amazon region, Colombia, Venezuela, Central America and Mexico; and Australia at the north and east coasts.

In Mexico, this forest is a dense community and the height of its trees varies from 20 to 30 m, with a homogeneous canopy, and diameters from 30 to 80 cm. This forest are located in tropical areas where half and some times until three quarters of the species lost their leaves for a 6 month period during the dry season of the year (Rzedowsky 1983). This forest grows in areas with annual average temperature higher than 20º C and less than 28º C, annual rainfall between 1000 and 1600 mm as a maximum, although in some areas like Jalisco could be 800 mm, a dry season between 5 or 7 months were almost all the species lost their leaves during some period of the year. These forest ecosystems are located from the sea level up to 800 m. Common species are: *Brosimum alicastrum, Aphananthe monoica*, in Jalisco, Colima and some part of Nayarit and Michoacán the most frequent species are the following: *Astronium, graveolens*, *Bernoullia flammea*, *Sideroxylon cartilagineum*, *Bursera arbórea*, *Calophyllum brasiliense*, *Cordia alliodora*, *Cordia elaeagnoides*, *Tabebuia donnell-smithii*, *Dendropanax arboreus*, *Enterolobium cyclocarpum*, *Ficus cotinifolia*, *Ficus involuta*, *Ficus mexicana*, *Hura polyandra*, *Luehea candida*, *Hymenaea courbaril*, *Lysiloma divaricatum*, *Sideroxylon capiri*, *Attalea cohune*, *Swietenia humilis*, *Tabebuia impetiginosa y Tabebuia rosea*. In the intermediate stratum the following species are outstanding: *Acacia langlassei*, *Apoplanesia paniculata*, *Trichospermum mexicanum*, *Bursera excelsa*, *Bursera simaruba*, *Jacaratia mexicana*, *Ceiba aesculifolia, Coccoloba barbadensis*, *Cordia seleriana*, *Croton draco*, *Cupania glabra*, *Esenbeckia berlandieri*, *Eugeniamichoacanensis*, *Euphorbia fulva*, *Exothea copalillo*, *Forchhammeria pallida*, *Inga laurina*, *Jatropha peltata*, *Plumeria rubra, Psidium sartorianum*, *Swartzia simplex*, among others. This type of vegetation can be found from Central Sinaloa up to Chiapas along the coastal line up to 1,200 m above sea level and in small areas in central Veracruz, central Chiapas and central and north Yucatan (Rzedowski y McVaugh, 1966, Pennington y Sarukhán, 1998).

Tropical Dry Forests

According to Lamprecht (1986) tropical dry forests vary from dense to very poor stand density, mostly xerophytic or deciduous in the dry season, which lasts from 5 to 7.5 months. They have a rainfall varying from 700 to 1000 mm/year, and sometimes more; they can have two strata, with poor floristic composition. This type of forest grows mostly in Africa: south of Sahara, the Eastern part including Kenya, Tanzania, and Zimbabwe. In North America and Central America: in the mountain range from Mexico to Costa Rica; in South America in the Chaco region, in the Pacific ocean side close to Guayaquil, Equator up to Northern Peru, and on the Atlantic ocean side in Venezuela, Colombia and Brazil. In Asia it can be found at the occidental monsoonal zone close to India, at the dry watershed in High Burman, Thailand, the Khorat watershed, and the dry monsoon region of the Sunda Islands.

In Mexico, these forests are located in tropical areas where the dominat species loose their leaves for a 6 month period during the dry season of the year (Rzedowsky, 1983). This type of forest grows in areas with an annual average temperature higher than 20º C, annual rainfall between 800 and 1200 mm as a maximum, a dry season between 7 or 8 months during, which almost all the species loose their leaves during some period of the year. These forest ecosystems are located from the sea level up to 1700 meters above sea level.

Tree height varies from 4 to 10 meters, although can reach 15 m. Frequently, the trunks of the trees are short, twisted and with branches starting close to the soil, tree crowns are sparse and extended, and a great number of species can sprout. The understory is very scarce and it can be seen only during the rain season. Lianas are abundant and epiphytes are limited to those from the bromeliaceae family such as the genus *Tillandsia*. Succulent plants are common and are represented by the genus *Agave*, *Opuntia*, *Lemaireocereus*, and *Cephalocereus*. Species with spines are not abundant. This plant community grows on hillsides, stony ground, and in sandy or clay shallow soils with good superficial drain. It has a wide geographical distribution on the Pacific coastline, especially in the Balsas river watershed and on hillsides of the Occidental mountain range from Colima to Sonora states in ravines. It extends from Baja California to Chiapas. At the side of the Gulf of Mexico it can be found in the region known as the Huasteca, and a large portion of Yucatan.

Frequent tree species on the Pacific coastline (Michoacan, Jalisco, Colima and Nayarit states) are: *Lysiloma divaricatum*, *Bursera excelsa*, *Bursera fagaroides*, *Ceiba aesculifolia*, *Comocladia engleriana*, *Cyrtocarpa procera*, *Lonchocarpus eriocarinalis*, *Lysiloma acapulcensis*, *Pseudosmodingium perniciosum*, *Spondias purpurea*, and *Trichilia americana* (Rzedowsky and McVaugh, 1996; Pennington and Sarukhan, 1998).

Land Classification Systems

Most land classification systems are based on the study of the physical and biological attributes of the land surface. These systems only differ in the classification unit concept in which the generation of maps is used for planning the different human activities carried out in a specific region.

In Australia, the Division of Land Research and Regional Survey of The Commonwealth Scientific and Industrial Research Organization (CSIRO) developed a system of geomorphological mapping for resource survey based on a concept of land units and land systems. The concept was designed to provide a basic and functional subdivision of landscape (Christian and Stewart, 1968). A land unit was defined as an area dominated by a land surface with similar genesis and with similar topography, soils, vegetation, and climate. A land system was assembled of land units, which are geographically and genetically related (Christian, 1958). This system was well adapted to rapid reconnaissance surveys of large areas based on information derived from aerial photographs, and it was widely used to map large areas of Australia and New Guinea (Mabbutt and Stewart, 1963).

Another land classification system is the one based on the landscape or geomorphological and edaphic criteria; the phisiographical survey is represented by CSIRO, the Military Engineering Experimental Establishment in England and the National Institute for Road Research in South Africa.

One more system is known as ecological typology represented by the French group "Centre D'Etudes Phytosociologiques et Ecologiques" based on regions made up of climatic, phisiographic, geological, and edaphic criteria, and vegetation types (Boyas, 1992). The basic unit in this system is the site or station, which defines a homogeneous unit based on climate, topography, geology, soil, and vegetation. In this system vegetation has more weight for territorial regionalization, because it is considered is the most exact expression of the interaction of environmental factors. According to Boyas (1992), this is the closest definition to the term called ecological unit in which the study to determine productivity, composition and structure of arboreal communities in Morelos state in Mexico was based.

Currently these kinds of land classification systems are widely used to support studies that to work with ecosystem and landscape ecology, which focuses on structure, the spatial patterns of landscape elements, and ecological objects (such as animals, biomass, and mineral nutrients); function, the flow of objects between landscape elements; and change, alterations in the mosaic through time (Forman and Godron, 1986).

In Mexico, several studies have been done using the phisiographical system (Ortiz and Cuanalo, 1984). Most of them were done to estimate land productivity for agricultural activities as a basis for the elaboration of management and conservation plans (Peña, 1974; Ponce and Cuanalo, 1977; Ortiz y Cuanalo, 1977; Rodriguez y Ortiz, 1982; Basurto and others, 1984; Soria and Ortiz, 1987; Salazar y Ortiz, 1987; and Terrazas, Ortiz and Vargas, 2002).

The use of the ecological typology methodology in Mexico has been applied to develop several studies to estimate the productivity capacity of the land for planning animal husbandry, agricultural, and forestry activities. The concept of ecological units has been used as the basic study unit to assess the best use aptitude of the land according to its productive potential. The National Institute for Statistics, Geography, and Informatics based on the French School has developed charts of potential use of the land for that entire country.

Studies to obtain ecological units charts for specific regions of some states such as Huitzilac, Morelos (Reyes and Boyas, 1983), Morones mountain range in Zacatecas (Vela y Boyas, 1984), and the region known as la Montaña in Guerrero (Toledo, 1984; Carabias and others 1987) have been developed for planning of agricultural and conservation activities.

The most important effort in applying this methodology was done by Boyas (1992) to define the ecological regionalization of Morelos state through the definition of ecological units for the most important arboreal communities and to assess the composition, structure, and wood productivity of the most important ecological units for tropical dry forests in the whole state. Climatic, phisiographic, geologic, soil, and current use of the soils 1: 250,000 scale charts were stratified and overlapped to define 130 ecological units; those with the biggest size were considered as more representative of the environmental conditions in the state; 22 covered 76 percent of the state surface area.

The composition, structure, and wood productivity of the tropical dry forest was studied through a systematic forest inventory with a sample intensity of 0.01 percent of the total area surface. The taxonomic studies showed the presence of 100 tree species, and the most important plant families were leguminosae and burseraceae; for each ecological unit the vertical stratification of the average stand was obtained according to their diametric structure; three arboreal strata were identified. Total volume and commercial volume were estimated for the 100 species and by ecological unit as an indicator of productivity. This study shows demonstrates that the ecological typology methodology constitutes a very good framework to assess forest potential for a region, and that productivity varies for each ecological unit, providing the basis to design and plan specific management plans for each one.

Materials and Methods

Area of Study

This study was carried out on a forested track of land known as “Arroyo Cuenca Quebrada,” in Tomatlan, Jalisco. This track of land has a total surface area of 4,462 hectares. It is located between the coordinates 105º 05’ West longitude and 19º 55 North latitude. It is located 70 km from Puerto Vallarta. The weather is considered as A w 1 (w). (I’) sub-humid tropical with rainfall in summer. The average total annual amount of rainfall is 1408 mm; the average temperature is 25.8º C, with an oscillation between 5º to 7º C (Garcia, 1988). Tropical deciduous and dry forests occupy 97 percent of the area; the remaining amount of land is mainly covered with grassland, a small amount of oak forest (5.7 ha), and of agriculture 5 ha. The intrusive igneous rocks are derived from the cretaceous period, and are mostly granite. According to the FAO/UNESCO soil classification system (2001) modified by the National Institute for Statistics, Geography and Informatics of Mexico (1989), this area has regosol eutric (unconsolidated mineral material of some depth, excluding coarse textured materials and materials with *fluvic properties,* with no diagnostic horizons other than an *ochric horizon*); Cambisol eutric, and cambisol chromic (soils with incipient soil formation. Beginning transformation of soil material is evident from weak, mostly brownish discoloration and/or structure formation below the surface horizon); Phaeozems haplic are more intensively leached in wet seasons. Consequently, they have dark, humus surface soils that are less rich in bases than surface soils of Chernozems and Kastanozems and Phaeozems, and have no signs of secondary carbonates in the upper meter of soil; and litosols (soils with less of 10 cm of depth to the bedrock). The area has an accidental topography with slopes from 5 to 20 percent. The average altitude above sea level varies from 128 to 760 m. The aspect in general in the study area is Southwest.

Methods

Ecological classification of the study area

Digital cartographic material of the GIS database created by Kruger (2000) at a scale 1:50,000 was used. The digital layers with vectorial data to define the ecological units were: Area.shp, Contours.shp, Presammpl.shp, Sample.shp, Geology.shp, Soils.shp, and Landuse.shp, and the layers with raster data used were DMH.grid, Exposition.grid and Hangneigung.grid. The stratification of the ecological units was done according to French methodology pointed out by Boyas (1992), overlapping maps. The GIS Arc View© with the geoprocessing wizard tool was used to overlay different layers of information and the generation of new ones. The specific functions used were dissolve features based on an attribute, merge themes together, clip one theme based on another, intersect two themes, union two themes, and assign data by location or spatial joint.

The main layer used was geology to overlap the different layers of information such as soils, digital altitude pattern, aspect, slope, and vegetation. Strata were defined according to their limits and combination of physical types and vegetation types. In this way each stratum was defined by 4 factors (geology, soils, vegetation, and altitude) giving origin to ecologic units.

Tree species composition assessment

A systematic sampling design was carried out. Distance between sampling lines was 500 m and between plots was 250 m. A pilot sample with 20 plots was used to estimate the coefficient of variation for diameter at breast height and compute the final sample size. A final sample size of 357 plots was taken with a 95 percent of confidence and sampling intensity of 0.4 percent. Each plot was located with a preprogrammed GPS with the data of the sampling grid; at the plot center a metallic rod was buried to allow the future plot relocation. Circular plots of three sizes were used. Circular 500 m^2 plots for recording data of adult trees, 100 m^2 circular subplots for intermediate size trees and 12.57 m^2 circular subplots for tree regeneration. At each plot the following information was recorded:

Control data. Plot number, UTM geographical coordinates, name of the responsible person for the information, date of the sampling, additional plot information such as erosion presence (no erosion, sheet erosion, channel erosion, and gully erosion), disturbance type (none, illegal cuttings, grazing, insect attack, other), and tree damage (high, medium, and low), use of the soil (forest, animal husbandry, agriculture).

Tree data. For all the trees over 5 cm of dbh, plot number, individual number, species name, dbh, total height, distance from the center of the plot to the tree, azimuth (from cero to 360 degrees), health status of the tree (good, regular, sick), damage (hollow up, bunch of stems, bifurcated, curve, decrepit, blunted, branchless, injured, sided, none, infested, half-alive) were recorded. For the 500 m^2 plot additional information was recorded such as commercial height, and average crown diameter.

Analysis of data. Digital cartographic material of the GIS database created by Kruger (2000) at scale 1:50,000 was used as starting point to create a wider database and expand the existing information, as well as to generate new information layers. The information from the forest inventory was cleansed, and stored in excel format for processing. This format allowed management of the files to be used with the Statistical Analysis System to estimate the central tendency parameters for the variables recorded at the forest inventory, in general for all the population, for each ecological unit.

Results and Discussion

Ecological Units (EU)

The map of EU for the track of land Arroyo Cuenca Quebrada, in Tomatlan, Jalisco was obtained. The main layer used was geology to overlap the different layers of information of soil, digital altitude pattern, aspect, slope, and vegetation. The bigger weight was given to vegetation, because it is the most exact expression of all the interaction of environmental factors, in the definition of the boundaries between EU (fig. 1). According to this map the study area has 19 EU (table 1), but only 14 covered with forest were considered relevant to this study. The most representative EU were those with the bigger coverage of surface area, pointed out at table 1 with numbers 6,7 and 8, which are covering 4,087.7 ha (91.5 percent) of the total area. Their altitude range only differentiates them.

Vegetation

The vegetation types found at the area correspond with those described by Rzedowski (1983) as tropical sub-deciduous forest and tropical dry forest. Ten EU with 4,255.1 ha (95.3 percent of the total area) were covered by tropical sub-deciduous forest; the remaining four EU are covered with tropical dry forest. The dominant vegetation families at the area are (table 2) leguminosae with 16 genera and 22 species, the euphorbiaceae family with 5 genera and 7 species, the moraceae family with 4 genera and 6 species followed by the myrtaceae family with 2 genera and 4 species. Dominant genera per family were for the leguminosae *Acacia* with 4 species, *Lonchocarpus* with 3 species, and *Lysiloma* with 2 species; euphorbiaceae with the genera *Croton* with 2 species, and *Cnidoscolus* with 3 species; moraceae with the genus *Ficus* with 3 species; myrtaceae with the genus *Psidium* with 3 species; burceraceae with the genus *Bursera* with 3 species; and the bignonaceae family with the genus *Tabebuia* with 4 species (table 2). These results coincided with those reported by Rzedowski y McVaugh, 1966, Rzedowski, 1983, Pennington y Sarukhán, 1998, and Boyas, 1992.

The total number of families found at the area was 39 families with 75 genera and 136 species. It is important to mention that 40 species were identified at the field only with common names, when the forest inventory was carried out, and further taxonomic identification work is

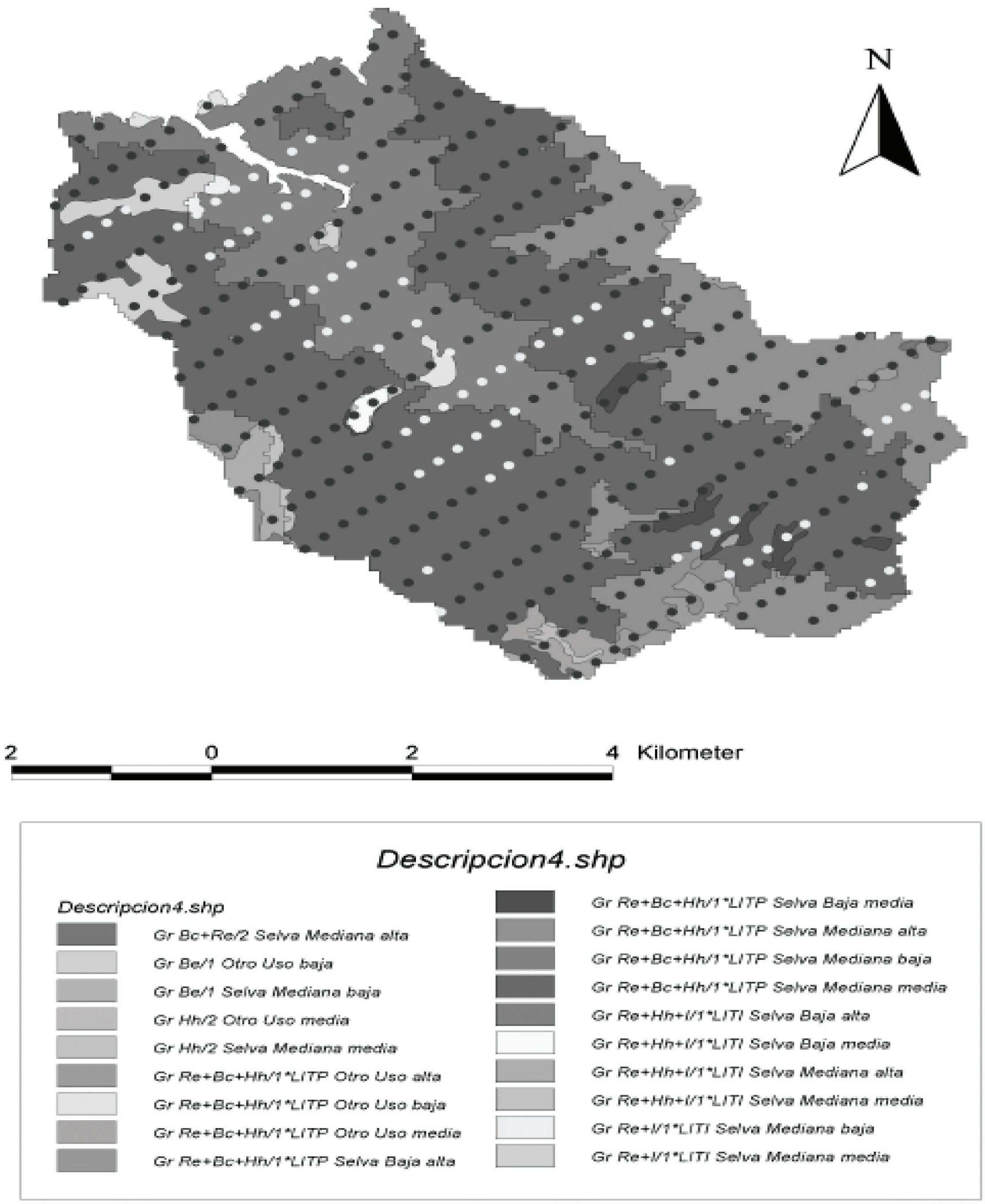

Figure 1. Ecological units at Arroyo Cuenca Quebrada, in Tomatlan, Jalisco, Mexico.

required; the list of species found in this study, together with other of their main characteristics are presented at the table 2.

Regarding plant families distribution by EU, the Ecological Unit with representation of the 39 families found in this study was the one identified as Gr Re+Hh+I/1*LITI Selva Baja media, with a surface area of 12.8 ha, indicating that there is high species diversity per unit of land, and this result also shows that tropical dry forest in this environmental conditions in Jalisco state is more diverse than tropical sub-deciduous forest (table 3). The subsequent EU with more families represented were Gr Re+Bc+Hh/1*LITP Selva Mediana media with 30 families, followed by the EU Gr Re+Bc+Hh/1*LITP Selva Mediana alta with 28 families, these last two EU cover a total surface area of 3,191.59 ha. the EU with the less number of families was Gr Be/1 Selva Mediana baja with 1 family (palmae) covering 4.52 ha,this situation could be a result of a disturbance occurrence such as intensive grazing or a fire, but more detailed studies are needed about stand dynamics in the long term to know the successional dynamics of this type of

Table 1. Ecological units at Arroyo Cuenca Quebrada, in Tomatlan, Jalisco.

Number	Ecological unit	Surface area (ha)	Surface area (%)
1	Gr Bc+Re/2 Selva Mediana alta	5.16	0.12
	Gr Be/1 Otro Uso baja	4.41	0.16
2	Gr Be/1 Selva Mediana baja	4.52	0.33
	Gr Hh/2 Otro Uso media	7.90	0.33
3	Gr Hh/2 Selva Mediana media	0.49	0.03
	Gr Re+Bc+Hh/1*LITP Otro Uso alta	52.98	2.13
	Gr Re+Bc+Hh/1*LITP Otro Uso baja	21.66	0.66
	Gr Re+Bc+Hh/1*LITP Otro Uso media	45.08	1.18
4	Gr Re+Bc+Hh/1*LITP Selva Baja alta	2.84	0.28
5	Gr Re+Bc+Hh/1*LITP Selva Baja media	58.78	2.66
6	Gr Re+Bc+Hh/1*LITP Selva Mediana alta	780.29	24.21
7	Gr Re+Bc+Hh/1*LITP Selva Mediana baja	896.11	13.78
8	Gr Re+Bc+Hh/1*LITP Selva Mediana media	2411.30	48.19
9	Gr Re+Hh+I/1*LITI Selva Baja alta	1.31	0.12
10	Gr Re+Hh+I/1*LITI Selva Baja media	12.80	0.35
11	Gr Re+Hh+I/1*LITI Selva Mediana alta	44.65	1.44
12	Gr Re+Hh+I/1*LITI Selva Mediana media	16.49	0.67
13	Gr Re+I/1*LITI Selva Mediana baja	8.21	0.28
14	Gr Re+I/1*LITI Selva Mediana media	87.88	3.10
	Total	**4,462.91**	**100%**

Gr= Granite, Bc= Cambisol cromico, Re= Regosol eutrico, Be= Cambisol cromico, Hh= Fezem haplico, /1 = thick texture, /2 = medium texture, LITI = soil fase litic cover with rocks from 10 to 50 cm, LITP= soil fase deep ltic with rocks from 50 to 100 cm, baja= 0-250 m, media= 251-500 m alta=501-760 m above sea level.

Table 2. List of species found at the Arroyo Cuenca Quebrada, in Tomatlan, Jalisco.

Species number	Species common name	Scientific name	Botanic family	Plant use	Wood clasification
001	Achiote	*Bixa orellana*	Bixaceae	The fruit is used as a coloring for chewing gum	
002	Aguacatillo, laurelillo	*Nectandra ambigens*	Lauraceae	Firewood	Soft wood
003	Ahuilote	*Vitex mollis*	Verbenaceae	The fruit is edible and together with the leaves are medicinal	
004	Algodoncillo	*Luehea speciosa*	Tiliaceae	Post and firewood	Low quality
005	Amolillo, jaboncillo	*Sapindus saponaria*	Sapindaceae		
006	Anona	*Annona purpurea*	Anonaceae	Edible fruit	
007	Árbol María	*Calophyllum brasilense*	Gutiferaceae	Sawmilling, furnitures and construction	Precious wood
008	Arrayán	*Psidium sartorianum*	Myrtaceae	Edible fruit,	Saw mill
009	Arrayancillo	*Eugenia fragans*	Myrtaceae	Postes, furnitures and construction	Common tropical
010	Arrayancillo negro				
011	Bejuco				
012	Bonete	*Jacaratia mexicana*	Caricaceae	Fruit edible and medicinal use	
013	Botoncillo, aucelote	*Cordia alliodora*	Boraginaceae	Posts, beams, and furniture	Saw mill
014	Brasil	*Haematoxylon brasiletto*	Leguminosae	Furnitures and construction and natural colorant	
015	Cabra	*Aphananthe monoica*	Ulmaceae	Posts.	Saw mill
016	Camotillo	*Dalbergia* sp.	Asteraceae		
017	Canelilla	*Croton* sp.	Euphorbiaceae	Sticks for crops.	Saw mill
018	Caoba, cobano	*Swietenia humilis*	Meliaceae	Sawmilling, furnitures	Precious wood
019	Capiri	*Masthicodendron capiri*	Sapotaceae		
020	Capomillo	*Trophis racemosa*	Moraceae		
021	Capomo	*Brosimum alicastrum*	Moraceae	Sawmilling, construction, and leaves and fruit for forage	Precious wood
022	Capulín	*Tremula micrantha*	Ulmaceae		
023	Caramuza				hardwood
024	Cedoso				
025	Cedro blanco	*Gyrocarpus jatrophifolius*	Hernandiaceae		High quality wood
026	Cedro rojo	*Cedrela odorata*	Meliaceae	Sawmilling, furnitures.	Precious wood
027	Ceiba, pochote	*Ceiba aesculifolia*	Bombacaceae	The fiber of the fruit is used for stuffing pillows	
028	Chachalaco				
029	Chicozapote	*Pouteria* sp.	Sapotaceae		
030	Chilte	*Cnidoscolus elasticus*	Euphorbiaceae	Chewing gum	
031	Chorunbo garruñolo				
032	Cinión, cinlón				

Table 2. *Continued.*

Species number	Species common name	Scientific name	Botanic family	Plant use	Wood clasification
033	Ciruelo	*Spondias purpurea*	Anacardiaceae	Edible fruit	
034	Clavellina	*Pseudobombax ellipticum*	Bombacaceae		
035	Cola de vaca				
036	Coloradillo				
037	Concha	*Pithecellobium lanceolatum*	Leguminosae	posts, fruit for forage	Saw mill
038	Copal	*Bursera heteresthes*	Burceraceae	Fruit use for inciense	
039	Copalillo	*Bursera excelsa*	Burceraceae	Construction	Saw mill
040	Cruzillo	*Randia laevigata*			
041	Cuamecate	*Anredera vesicaria*	Basellaceae	Hornamental and medicinal	
042	Cuata	*Vitex piramidata*	Verbenaceae	Se wood use for doors	Saw mill
043	Cuata laca	*Caesaria dolichophylla*	Flacurtiaceae		
044	Cuate	*Eysenhartia polystachya*	Leguminosae	Posts and constuction	High quality wood
045	Cuernillo			Posts	Long lasting wood
046	Cuerno de toro			Posts	
047	Cuero de Indio	*Lonchocarpus longopedicellatus*	Leguminosae	Porous wood	
048	Cuil				
049	Cuirí				
050	Culebro, amargoso	*Astronium graveolens*	Anacardiaceae	Sawmilling, furnitures and construction	High quality wood
051	Embele			Wood use for handcrafts	
052	Encino	*Quercus glaucescens*	Fagaceae	Industrial use	
053	Frutilla				
054	Gallinilla				
055	Garrapato	*Lonchocarpus constrictus*	Leguminosae	Posts	High quality wood
056	Garruño negro				
057	Gavilancillo				
058	Gobonero				
059	Granadillo	*Platymiscium lasiocarpum*	Leguminosae	Posts and construction	High quality wood
060	Guaiparín				
061	Guajillo	*Leucaena glauca*	Leguminosae	Posts	High quality wood
062	Guasima	*Guazuma ulmifolia*	Sterculiaceae	Sawmilling, furnitures and construction, fruit for forage	High quality wood
063	Guayabilla	*Psidium guineense*	Myrtaceae		
064	Guayabo	*Psidium guajava*	Myrtaceae		
065	Habillo	*Hura polyandra*	Euphorbiaceae	Sawmilling, furnitures	High quality wood
066	Hediondillo	*Cassia atomaria*			
067	Higuera	*Ficus obtusifolia*	Moraceae	Fruit and foliage use for forage	
068	Hincha huevos	*Comocladia engleriana*	Anacardiaceae	Posts and construction	harwood
069	Hormiguillo, guarumbo, trompeta, cuitapilli	*Cecropia obtusifolia*	Cecropiaceae	Construction	High quality wood
070	Huevo de gato	*Thevetia ovata*	Apocynaceae	Construction.	sawmill
071	Huizache	*Acacia farnesiana*	Leguminosae	Posts and fruit for forage	sawmill
072	Huizapol				
073	Huizcolote	*Acacia cymbispina*	Leguminosae	Posts	sawmill
074	Jarretadera	*Acacia hindsii*	Leguminosae		
075	Juan Pérez	*Pseudosmodingium perniciosum*			
076	Juanita	*Halimium glomeratum*	Cistaceae	Firewood	firewood
077	Juaquinicuil	*Inga jinicuil*	Leguminosae	Edible fruit and for forage.	
078	Lechoso				
079	Llora sangre, sangre de grado	*Croton draco*	Euphorbiaceae	Packingboxes, coloring, and bark for medicinal purposes	
080	Majahua	*Heliocarpus pallidus*	Tiliaceae	Construction	sawmill
081	Mameycillo				
082	Mano de león	*Oreopanax xalapensis*	Araliaceae		
083	Maravilla				
084	Margarita	*Karwinskia latifolia*	Rhamnaceae	Construction	sawmill
085	Mataiza	*Sapium pedicellatum*	Euphorbiaceae	Sin uso	
086	Mora	*Chlorophora tinctoria*	Moraceae	Posts and construction	sawmill
087	Murciélago			Wood for tool handles	sawmill
088	Nance	*Byrsonima crassifolia*	Malpigiaceae	Edible fruit	edible
089	Naranjillo			Posts, and tool handles	sawmill
090	Naranzuchil				
091	Obo, ravelero	*Sciadodendron excelsum*	Araliaceae		
092	Órgano	*Pachycereus pecten-aboriginum*	Cactaceae	Edible fruit	edible
093	Otras				
094	Palma coyul	*Acrocomia aculeata*	Palmae	Edible fruit, wood for beams	
095	Palma real	*Sabal mexicana*	Palmae	Leaves used as a house roof	sawmill
096	Palo blanco	*Tabebuia* sp.	Bignoniaceae	Construction	sawmill
097	Palo bobo	*Ipomea arborescens*	Convolvulaceae		
098	Palojiote				
099	Pan pan	*Cnidoscolus tubulosos*	Euphorbiaceae		

Table 2. *Continued*.

Species number	Species common name	Scientific name	Botanic family	Plant use	Wood clasification
100	Papelillo	*Bursera simaruba*	Burceraceae	Sawmilling, furnitures and construction	sawmill
101	Parota	*Entherolobium cyclocarpum*	Leguminosae	Sawmilling, furnitures and construction, edible fruit and for forage	Precious wood
102	Parotilla	*Poeppigia procera*	Leguminosae		
103	Pata de res				
104	Pata de venado	*Bahuinia cungulata*	Leguminosae	Posts	hardwood
105	Pinolillo, tzinacacao	*Andira inermis*	Leguminosae	Furniture and doors	sawmill
106	Polvillo	*Lonchocarpus* sp.	Leguminosae		
107	Pozolillo				
108	Primavera	*Tabebuia donnell-smithii*	Bignoniaceae	Sawmilling and furniture	precious wood
109	Quebramuelas	*Cupania dentata*	Sapindaceae	Wood for tool handles	sawmill
110	Quemador	*Cnidoscolus* sp.	Euphorbiaceae		
111	Raspa vieja	*Curatella americana*	Dilleniaceae		
112	Roble	*Quercus* sp.	Fagaceae		
113	Rosa morada, amapa	*Tabebuia rosea*	Bignoniaceae	Sawmilling and furnitures	precious wood
114	Saladillo				
115	San Antonio				
116	Suelda	*Agonandra racemosa*		Posts	sawmill
117	Tacote				
118	Tacotillo				
119	Tahuitole	*Pterocarpus orbiculatus*	Leguminosae	Posts	sawmill
120	Tampiziran	*Dalbergia congestiflora*	Leguminosae	Sawmilling and furnitures	High quality wood
121	Tancua				
122	Tempuche				
123	Tepame	*Acacia pennatula*	Leguminosae		
124	Tepeguaje	*Lysiloma acapulcensis*	Leguminosae	Posts and construction	sawmill
125	Tepemezquite	*Lysiloma microphylla*	Leguminosae	Posts and construction	sawmill
126	Tezcalame	*Ficus cotinifolia*	Moraceae	Fruit for forage	
127	Tintilagua				
128	Trementinillo				
129	Uña de gato	*Mimosa benthami*	Leguminosae	Posts for construction	
130	Vainero				
131	Verdecillo, palo fierro, amapilla, amapa prieta	*Tabebuia chrysantha*	Bignoniaceae	Posts and tool handles	sawmill
132	Xilomecate, panicua, rosa amarilla, huevo de burro	*Cochlospermum vitifolium*	Cochlosperm-aceae	Fiber used to make ropes	
133	Zacalozuchilt, corpo, flor de mayo, palo de oído	*Plumeria rubra*	Apocynaceae	Posts	
134	Zalate	*Ficus petiolaris*	Moraceae	Fruit for forage	forage
135	Zapotillo	*Couepia polyandra*	Rosaceae	Sawmilling, furnitures and beams	hardwood
136	Zorrillo	*Zanthoxylon* sp.	Rutaceae	Wood for tool handles	sawmill

vegetation at the study area. Regarding this kind of studies the plots established in this research has been planned as a permanent plots, and a series of different studies will be carried out in the long term. This study constitutes the first approach to the processing of part of the total database of this research.

Conclusions

The ecological typology methodology with the use of GIS constitutes a very good tool to assess the environmental conditions and the forest potential for a region. The definition of ecological units provides the basis to design and plan specific management, and monitoring plans for each one in particular and the whole region.

The ecological regionalization done in this research allows the identification of specific growing conditions and the definition of ecological requirements for different plant species to develop through an ecological range.

One hundred thirty six species were recorded in all the ecological units. The most diverse ecological unit was Gr Re+Hh+I/1*LITI Selva Baja media with 39 plant families.

The dominant vegetation families at the area were leguminosae, euphorbiaceae, moraceae, and myrtaceae.

Dominant genera were *Acacia*, *Lonchocarpus*, *Lysiloma, Croton, Cnidoscolus*, *Ficus, Psidium, Bursera* and *Tabebuia*.

This technique has potential application to a wide spectrum of ecological problems and to the management and conservation of biodiversity. However, its most potential application could be in inventorying and monitoring natural resources, because the effective application of ecological knowledge to problems of ecosystem management requires the utilization of a variety

Table 3. Plant families distribution for EU at Arroyo Cuenca Quebrada, in Tomatlan, Jalisco.

Family/EU	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Anacardiadeae				X	X	X	X	X	X	X	X	X	X	
Anonaceae	X			X	X	X		X		X			X	X
Apocynaceae						X		X		X				
Araliaceae						X		X		X		X		
Asteraceae										X				
Basellaceae								X		X				
Bignoniaceae	X		X	X	X	X		X		X		X	X	X
Bixaceae								X		X				
Bombacaceae						X		X	X	X			X	
Boraginaceae						X		X		X			X	X
Burceraceae	X		X		X	X	X	X	X	X	X	X	X	X
Cactaceae									X	X				
Caricaceae				X	X	X		X		X		X	X	X
Cecropiaceae						X		X		X		X	X	
Cistaceae						X		X		X			X	X
Cochlospermaceae						X		X	X	X	X		X	
Convolvulaceae								X	X	X				
Dilleniaceae								X		X			X	
Euphorbiaceae	X		X	X	X	X	X	X	X	X	X	X	X	X
Fagaceae				X		X				X				
Flacurtiaceae										X			X	X
Gutiferaceae						X		X		X				
Hernandiaceae			X			X	X	X	X	X				
Lauraceae						X		X		X				
Leguminosae				X	X	X	X	X	X	X	X	X	X	X
Malpighiaceae								X	X					
Meliaceae						X		X		X			X	
Moraceae					X	X		X	X	X		X	X	X
Myrtaceae	X		X			X		X		X			X	
Palmae	X	X		X	X	X		X		X				X
Rhamnaceae										X		X	X	
Rosaceae						X		X		X			X	
Rutaceae						X		X		X			X	
Sapindaceae						X		X	X	X	X		X	X
Sapotaceae						X		X		X			X	
Sterculiaceae	X			X	X	X	X	X		X	X		X	X
Tiliaceae					X	X		X	X	X	X	X	X	X
Ulmaceae						X		X		X	X		X	X
Verbenaceae						X		X		X			X	
Total	**7**	**1**	**4**	**9**	**11**	**28**	**8**	**30**	**13**	**39**	**12**	**12**	**24**	**18**

of information (from historical records, the research data, to observations obtained by direct management and disturbances effect) at different aggregations levels that this methodology can provide.

It is recommended to develop further taxonomic identification work and further studies on ecological succession to provide an understanding of successional dynamics, and the interrelationship between successional processes and other community attributes associated with stability, diversity, and dominance.

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