How the areas with specific kind of vegetation have been changing through the time in Durango State Mexico.
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Abstract
Areas with specific kind of vegetation were estimated and compare them to see how they have been changing through time, because of many factors such as fires, changes of the land to agricultural use (using slash and burn), soil degradation because of improper management (from primary forest to other kind of forest), and so on. This study was developed for the area of Durango State, Mexico. The data were provided for INEGI (National Institute of Geography and Informatics) for the years 1994, 2002 and 2007. The kinds of vegetation were grouped in nine types (eight of natural vegetation and agriculture) which are coniferous forest, quercus forest, mountain mesophyll forest, deciduous forest, semi-deciduous forest, pastureland, xerophilous scrub, mesquite and agriculture. Two periods of time are identified, the first one from 1994 to 2002 (18 years) and the second one from 2002 to 2007 (5 years). The general trends in both periods are. The kinds of natural vegetation that began a specific trend in the first period and kept it in the second period were coniferous forest, pastureland and xerophilous scrub with a downward trend; deciduous forest, semi-deciduous forest and mesquite have an upward trend. In the second period quercus forest and semi-deciduous forest started a downward trend, and mesquite an upward trend. In a final balance for the first period it was lost 189.7 km$^2$ (0.18 %) of natural vegetation (10.5 km$^2$ per year) and for the second period it was lost 2094.8 km$^2$ (2%) of natural vegetation (419 km$^2$ per year).

Introduction
The main objective of this study is the estimation of the areas with different kinds of vegetation according to the data provided for the years 1994, 2002 and 2007. Besides to compare them to see how they have been changing through time because of many factors such as fires, changes of the land to agricultural use (using slash and burn), soil degradation because of improper management (from primary forest to other kind of forest), and so on.

The quantification of the vegetal cover in quantity and quality is becoming more important each day because these changes have had an impact in the liberation of CO$_2$
into the atmosphere (global warming) and the productivity (the wood production is smaller). It is also necessary to create consciousness in people and try to avoid or reduce the illegal cutting of trees. There are many similar studies by official institutions that show the kinds of natural vegetation but it is necessary to compare the quantity of these resources and calculate some indicators to see how they are reducing.

**Literature review**

Vegetation types in the state of Durango present a sharp contrast, due to the complex relationship among a number of natural factors, including: the terrain, altitude, latitude, climate, soil, etc. The Sierra Madre Occidental (of which a portion is on west of the state), acts as a natural barrier that traps the humid winds from the Pacific Ocean and causes marked aridity in the interior region of the continent.

In 1963 it appeared the work "The Vegetation Types of Mexico and its classification" by F. Miranda and E. Hernández Xolocotzi, though the work has no mapping information it has been the basis of which many authors have gone out for classification of plant communities for various cartographic works.

In 1971 appeared the work "Map of Vegetation Types of the Mexican Republic of Mexico" at 1:2 000 000 with a brief description and which generally follows the classification system of Miranda and Hernández X.

In 1978 it appeared the work "Vegetation of Mexico" by Jerzy Rzedowski who came to present a new approach to the classification of plant communities in the country, made a map scale 1:8000000. This work is obligatory reference for vegetation studies in the country (CONAFOR, 2010).

*In this project it was done a complete analysis of how the specific kid of vegetation has been changing in Durango State, Mexico. It was conducted using the most updated data that there are so far. And compare them with other studies made in the past. It is important to have updated data to show people who make the important decisions which are the new trends and how the current state of natural resources is. It would let people to take informed decisions.*

**Methodology**

1) As first step, the data were geo-referenced with the referencing information that was provided by INEGI. Which is the following:

```
CCL_INEGI
Projection: Lambert_Conformal_Conic
False_Easting: 2500000.000000
False_Northing: 0.000000
Central_Meridian: -102.000000
Standard_Parallel_1: 17.500000
Standard_Parallel_2: 29.500000
Scale_Factor: 1.000000
Latitude_Of_Origin: 12.000000
Linear Unit: Meter

GCS_WGS_1984
Datum: D_WGS_1984
```
2) The data were provided for the complete country. Therefore, it was proceeded to set apart just the polygons corresponding to Durango State using the GIS tools: intercept.

3) The areas of each polygon were calculated (using the option <Calculate Geometry>)

4) To identify the criterion used to classify the kinds of vegetation was analyzed each field to find which kind of information it has. It was done using the option <Selection by attributes>

5) Once that the criterion was identified the capability <Sumarize> was used to calculate the different areas of each kind of vegetation according with this criterion, since they are disperse around the state. Three tables with the essential information were created (one for each year) in text format to be used in Excel and create the different plots. The tables created show the kinds of vegetation and the areas of each one for the different years of this study.

**Application, results and discussion**

1) Localization of the study area.
Durango State is located northwest of the central part of Mexico, between the parallels 22° 17' and 26° 50' north latitude and between the meridians 102° 30' and 107° 09' west longitude. In the southern part, the Tropic of Cancer passes five miles away from El “Mezquital” into south.

![Fig. 1. Localization of Durango State.](image_url)

Climate
One of the determining factors for the distribution of climates in the state of Durango is the barrier formed by the Sierra Madre Occidental, which stops the wet winds and
generates in the western region a maritime climate, semitropical, generally with high temperatures, more or less uniform throughout the year, abundant rainfall and high humidity.

With exception of the mentioned region, in most part of the mountain, due to its altitude, has a semi-humid climate, temperate or semi-cold, which becomes warm and semi-dry on the eastern side of the mountain and much of the central strip of the state, and this becomes arid and semi-dry in the east of the valleys and frankly dry in the eastern part of the state, which is very extreme, of continental type, with only small patches of temperate climate in the insolated mountains (Gobierno de Estado de Durango. (2005)).

Major ecosystems
The state of Durango has four distinct regions: The Semi-desert region, the region of the Valleys, the Sierra region and “las Quebradas” region.

Semi-desert region is located in the northeast of the state and includes the municipalities of Hidalgo, Mapimi, Tlahualillo, San Pedro del Gallo, San Luis del Cordero, Nazas, Lerdo, Gómez Palacio, Cuencame, Santa Clara, General Simon Bolívar and San Juan of Guadalupe. Most of the land is flat and the weather is dry, it rains very little, so there is no humidity, very hot in summer and too cold in winter.

The region of the Valleys is located in the central part of the state and includes the municipalities of Nombre de Dios, Durango, Nuevo Ideal, Canatlán, Guadalupe Victoria, Pánuno of Coronado, Poanas, Súchil, Vicente Guerrero, Ocampo, San Bernardo, Inde, Conet Comonfort, El Oro, Rodeo, San Juan del Rio and White Rock. The valley lands are flat and good for agriculture. Many of these lands are irrigated with water from the rivers Nazas, Florido and Tunal, which pass through this area. There are also several dams and lakes.

The Sierra Region occupies mainly the western top of Durango State. It extends from the northern town of Guanacevi to the southern municipality of Mezquital. It includes all the municipalities of Guanacevi Tepehuanes and part of Santiago Papasquiaro, Topia, Canelas, Otáez, Tamazula, San Dimas, Pueblo Nuevo, Mezquital, Durango, and San Bernardo Ocampo. In the mountains the terrain is hilly, during the winter the climate is very cold, ice and snow often falls. There is also much rain during the summer.

“Las Quebradas “ region is located in the lower western part of Durango state, it covers part of the municipalities of Mezquital, Pueblo Nuevo, San Dimas, Otáez, Santiago Papasquiaro, Tamazula, Topia, Canelas and Tepehuanes. The topography of this region has very different shapes, with deep ravines and very high cliffs (Instituto Nacional para el Federalismo y el Desarrollo Municipal, 2005).
2) Data used in this work.
Data were provided by National Institute of Statistics and Geography (INEGI), which is an institution in charge of collecting official data in Mexico. The data that INEGI provided were three files in shapefile format which contain the main kinds of vegetation; the reference year is the year in which the data were collected.

a) Series II: It was elaborated between 1993 and 1999 (reference year is 2002).
b) Series III: It was elaborated between 2002 and 2005 based in Landsat-ETM images of the years 2002 and 2003. It uses the datum ITRF92. The scale is 1:250,000. (reference year is 2002)
c) Series IV: It was elaborated between 2007 and 2009 with spot 5 images (resolution of 10 m) (reference year is 2007).

The Series I is yet in analogical format and it was not provided.

The data that were provided are shapefiles with the different kinds of vegetation grouped according to the classification system proposed by Rzedowski (1978). The basis of this grouping is according to ecological affinity. A brief and general description of them is the following.

Coniferous forest
Plant formations of temperate, humid and sub humid areas comprised by evergreen gymnosperms. In Mexico are found practically from the sea level to 3 000 meters above sea level (masl).
Quercus forest
Plant communities comprised by the genus Quercus (Encinos, oaks). In Mexico, except with very arid conditions, they are found practically from the sea level up to 2,800 meters above sea level. They are closely related with pine forests.

Mountain mesophyll forest
This plant ecosystem is characterized by the presence of tree dense vegetation tree with epiphytes and ferns is mainly located in mountains, canyons and sites where conditions of humidity are favorable. In Mexico, they are located between 600 and 3200 masl.

Deciduous forest
These plant formations of tropical and arid origin are characterized by more than 75% of the species within them lose their leaves during the dry season. It has trees over 15 m in height and most of them lose leaves during the dry season.

Semi-deciduous forest
Plant formations which 50 and 75% of their species lose their leaves during the driest time of year.

Pastureland
These ecosystems are constituted by herbaceous communities in which dominate grasses and graminoids. In some cases, they have natural origin, but in others cases, they are formed due to disturbance of others kinds of vegetation. In Durango State this vegetation is being intensive grazing, usually by messy and uncontrolled livestock herds, which causes the vast majority of rangelands present a strong overgrazing, natural grassland is dominated by grasses, especially Bouteloua spp. (navajita grass, banderilla) and Muhlenbergia spp. (liendrilla grass).

Xerophilous scrub
This plant ecosystem is typical of arid and semiarid regions of Mexico and consists basically of microphyllous and thorny shrubby communities. In Durango state it is comprised by shrub with small-leave items with or without spines. There is a frequent predominance of Larrea spp. (gobernadora) in these places, the cactus are also common elements. The rosetofilo desert scrub occupies the slopes of hills and ridges of the interior plateau, on thin, rocky soils. It is characterized by shrubby species of long narrow leaves clustered in rosette, as the Agave spp. (maguey).

Mesquite
Vegetable community dominated mainly by mesquites (Prosopis spp.). They are thorny trees from 5 to 10 m of height in conditions of humidity, but in arid conditions it is grown as a bush. It is grown often in lands of deep soil and in alluvium close to runoffs and its development is associated to the presence of a deep aquifer. It is common to find this
community mixed with other elements such as huizache (Acacia spp.), palo fierro (Olneya tesota), palo verde (Cercidium spp.) and guamuchil (Pithecellobium dulce).

The mesquite is considered a very important natural resource for the semiarid and dry zones of the country, due to the different uses that it has as food for the cattle and for human consumption. The wood is utilized for flooring, parquet, hands for tools, firewood and coal among others. Due to the characteristics of the floor where is located it is eliminated constantly to incorporate lands to the agriculture.

Agriculture
In this category are the different types of agriculture that are developed in Durango. Forest plantations, cultivated forests and cultivated pastures are also included. In Durango it is important the production of corn, beans, sorghum, alfalfa and apple (Source: Gobierno de Estado de Durango. (2005)).

3 Results
The next figure shows the maps with the different kinds of vegetation for los years 1994, 2002 and 2007.

Fig. 3 Maps of vegetation in Durango State resulting of the analisis.
The areas resulting along with the respective percentage are presented in the next table.

<table>
<thead>
<tr>
<th></th>
<th>1994 Area (Km$^2$)</th>
<th>%</th>
<th>2002 Area(Km$^2$)</th>
<th>%</th>
<th>2007 Area(Km$^2$)</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>CONIFEROUS FOREST</td>
<td>36551.2</td>
<td>30.7</td>
<td>36192.6</td>
<td>30.4</td>
<td>35845.1</td>
<td>30.1</td>
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<td>QUERCUS FOREST</td>
<td>14360.4</td>
<td>12.1</td>
<td>14666.0</td>
<td>12.3</td>
<td>14293.5</td>
<td>12.0</td>
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<tr>
<td>MOUNTAIN MESOPHYLL FOREST</td>
<td>4.3</td>
<td>0.0</td>
<td>4.3</td>
<td>0.0</td>
<td>4.3</td>
<td>0.0</td>
</tr>
<tr>
<td>DECIDUOUS FOREST</td>
<td>4843.3</td>
<td>4.1</td>
<td>4909.3</td>
<td>4.1</td>
<td>5283.1</td>
<td>4.4</td>
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<tr>
<td>SEMI-DECIDUOUS FOREST</td>
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<td>140.9</td>
<td>0.1</td>
<td>127.0</td>
<td>0.1</td>
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<td>PASTURELAND</td>
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<td>21085.6</td>
<td>17.7</td>
<td>20024.9</td>
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<tr>
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<td>22.4</td>
<td>26663.3</td>
<td>22.4</td>
<td>25916.3</td>
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<td>MESQUITE</td>
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<td>0.3</td>
<td>452.3</td>
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<td>AGRICULTURE</td>
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<td>12.5</td>
<td>15099.5</td>
<td>12.7</td>
<td>17194.3</td>
<td>14.4</td>
</tr>
</tbody>
</table>

Fig. 4. Areas (km$^2$) and percentages of the different kinds of vegetation in Durango State.

For a fast visualization and comparison of the results, the next two tables were generated.

![Comparison Chart](image-url)

Fig. 5. Comparison of the areas (km$^2$) of the different kinds of vegetation in Durango State.
Fig. 6. Comparison of the percentages of different kinds of vegetation for the three years.

Also the different kinds of vegetation were grouped to compare this area with the area of agriculture. The next table was generated showing areas (km$^2$) and percentages.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>%</td>
<td>Area</td>
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<td>NATURAL VEGETATION</td>
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<td>87.5</td>
<td>104041</td>
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<tr>
<td>AGRICULTURE</td>
<td>14909.8</td>
<td>12.5</td>
<td>15099.5</td>
</tr>
</tbody>
</table>

Fig. 7. Areas (km$^2$) and percentages of natural vegetation and agriculture in the three years.

To have a better visualization of the results, the next two plots were generated.
Fig. 8. Comparison of the areas (km$^2$) of natural vegetation and agriculture in the three years.

Fig. 9. Comparison of the percentages of natural vegetation and agriculture in the three years.
4. Analysis of results

According to fig 4 the last year that this study covered (2007), the most abundant vegetation types are coniferous and quercus forest, which both cover 42.1 % of the state, in deep canyons of the mountain. Semi-deciduous and deciduous forest are distributed mainly in the west of the state, covering 4.5%. At the foot of the eastern slope of the mountain, there are considerable expanses of pastureland, an important resource for livestock, occupying 16.8 %. In the central and northeastern part, the vegetation consists of various types of scrub covering 21.8 % of the territory. Agriculture is developed in flat areas and slight slope, with deep soils and moderately deep, occupies 14.4 % of the area. The rest of the state area (0.4%) is covered by mesquite.

Forests in the state occupy the greater part of the Sierra Madre Occidental where are widely distributed tree masses of Pinus spp. (Pine) and Quercus spp. (Quercus), most of them are dominated by pine and mixed communities of pine and quercus. Especially on the Pacific side, there is the deciduous forest.

Pasturelands form a transitional area between temperate forests and vegetation in arid areas. This is in the central part from north to south.

The scrub is widely distributed in the arid part of the state in the east part of the state.

Land used to agriculture are mainly concentrated at the foot of the mountains in the center and east of the state where there are rain fed agriculture and land with irrigation, and to the northeast in the Comarca Lagunera where the lands have irrigation infrastructure.

Conclusions

Two periods of time are identified. The first one from 1994 to 2002 and the second one from 2002 to 2007.

The general trends in both periods are:
1) Coniferous forest, pastureland and xerophilous scrub have a downward trend
2) Agriculture has an upward trend
3) Deciduous forest, semi-deciduous forest and mesquite have an upward trend.
4) The mountain mesophyll forest keeps the same amount of vegetation.

The trends in the second period are:
5) Quercus forest and semi-deciduous forest started a downward trend.
6) Mesquite started an upward trend.

And as general conclusions,
7) In the first period, it was lost 189.7 km$^2$ of natural vegetation what is equivalent to 0.18 % of natural vegetation.
8) In the second period, it was lost 2094.8 km$^2$ that is equivalent to 2 % of natural vegetation.
9) In total (both periods), it was lost 2284.5 km$^2$ that is equivalent to 2.2 % of natural vegetation.

References


