CienciAgro
JOURNAL OF AGRICULTURAL SCIENCE AND TECHNOLOGY
ISSN 2072-1404 (PRINTED) - 2077-317X (ON LINE)

CienciAgro (2014) 3(1): 1 - 20
Recibido: 6/09/2014
Aceptado: 28/10/2014
Artículo científico original
www.institutoagrario.org

Deforestation Rates in the Mexican Huasteca Region (1976-2011)

Tasas de deforestación en la Región Huasteca de México (1976-2011)

Carmelo Peralta-Rivero[1], Carlos Contreras Servín[1], M. Guadalupe Galindo Mendoza[1], Marcos Algara Siller[2], Jean François Mas Caussel[3]*

[1] Universidad Autónoma de San Luis Potosí - Coordinación para la Innovación y la Aplicación de la Ciencia y la tecnología, Zona Universitaria, San Luis Potosí, SLP, México, e-mail: peralta.carmelo@gmail.com
[2] Faculta de Ingeniería, Universidad Autónoma San Luis Potosí, México
[3] Centro de Investigaciones en Geografía Ambiental, Universidad Nacional Autónoma de México.
** Autor de correspondencia*

Abstract

The current study aims to analyze temporal land use and land cover changes in the Huasteca region. We used cartographic information of land use and vegetation for the years 1976, 1993, 2002, 2007, and 2011, with a scale of analysis of 1:250,000 from the National Institute of Statistics and Geography of Mexico. The cartography data was corrected, standardized, and affected areas by deforestation were quantified and mapped. Different techniques of Geographic Information Systems were developed to demonstrate that process of land use and land cover changes have occurred in 17.43% of the region's surface. Agriculture and the increase of pasture could be identified as the main human-induced activities that have led to the modification of the forest covers. The forest and rain forest were affected by deforestation and the rate of change was higher than the national average, mainly in the period 1976-2002. Further important alterations include a change from natural land cover to non-original land cover affecting an area of 4,874.28 km^2 between 1976 and 1993, and 2,474.93 km^2 in the period 1993-2002. Smaller changes could be detected for the periods 2002-2007 and 2007-2011. Mapping for the years of analysis made it possible to identify the land use and land cover changes in the Huasteca region. The techniques used are tools that can be employed to assess the negative impact on the vegetation, and to propose alternatives for the management and sustainable use of natural resources.

Keywords: Land use change, deforestation, GIS, temporal analysis, Huasteca

Resumen

El presente estudio tuvo como objetivo analizar los cambios temporales de uso y cobertura de suelo en la región Huasteca de México. Utilizamos información cartográfica de uso de suelo y vegetación para los años 1976, 1993, 2002, 2007 y 2011 con una escala de análisis de 1:250,000 del Instituto Nacional de Estadística y Geografía de México. La información cartográfica fue corregida, estandarizada y se cuantificaron y mapearon las principales áreas afectadas por deforestación. Diferentes técnicas de Sistemas de Información Geográfica fueron desarrolladas para demostrar que los cambios de uso y cobertura de suelo ocurrieron en 17.43% de la superficie de la región. La agricultura y el incremento de pasto pueden ser identificadas como las principales actividades humanas que han modificado la cobertura forestal. Los bosques y selvas fueron afectados por la deforestación con tasas de cambios más alta que la tasa promedio a nivel nacional, principalmente para el periodo 1976-2002. Otras alteraciones

importantes incluyen un cambio de las coberturas naturales de suelo hacia las coberturas no originales de suelo afectando a un área de 4,874.28 km^2 entre 1976 y 1993, y 2,474.93 km^2 en el periodo 1993-2002. Cambios menores pudieron ser detectados para los periodos 2002-2007 y 2007-2011. El mapeamento para los años de análisis hizo posible la identificación de los cambios de uso y cobertura de suelo en la región Huasteca. Las técnicas utilizadas son una herramienta que pueden ser usadas para evaluar impactos negativos en la vegetación y proponer alternativas para el manejo y uso sostenible de los recursos naturales.

Palabras clave: Cambios de uso de suelo, deforestación, SIG, análisis temporal, Huasteca

INTRODUCTION

Humans are the main transformer of the world's ecosystems (Vitousek et al., 1997) and its impact had generated worldwide biodiversity loss and global warming, regional scale alteration of hydrological cycles, deforestation, loss of habitat and changing the distribution and abundance of wildlife (Marquez-Linares et al., 2005).

Also, it has provoked the generation of differentiated spatial patterns of land use change which, generally, are reflected in the loss of areas with natural vegetation such as temperate or tropical forests (López-Blanco, 2005).

This ambition to convert forests and rain forests into land for livestock production and agriculture has caused annual deforestation rates of up to 2% in the world's rain forests (Dirzo and García, 1995; Castillo-Santiago et al. 2007; Pacheco et al. 2009). In the case of the Mexican Republic, 52% of the country's total surface of 1,945,748 km^{2}are covered by forests, rain forests and large areas of scrublands with tree vegetation that reach a height of up to 3 meters (Ricker, 2010).

However, the National Forest Inventory of Mexico for the year 2000 registered a loss of 36% with regard to forest and rain forest ecosystems (Ricker 2010). According to Velazquéz et al. (2002), deforestation rates in Mexico varied between -0.25 and -1.02% during the period from 1976 to 2000, indicating a loss of 0.25 and 1.02% of forest cover per year.

The Huasteca region for instance has been historically known for producing many forest resources. Nonetheless, forest cover has been modified in various ways as a result of human-induced activities. Different biophysical factors come together with human-induced activities such as agriculture and livestock production, which may have an important impact on the transformation of ecosystems (Algara, 2009). The most important alteration can be observed with regard to rain forests and forests (Quinteros, 2012). Furthermore, the modernization of productive activities have accelerated and deepened these changes, due to the fact that the age of industrialization provoked the increase of livestock herding, the demand for wood and the need for wood-derived products (Aguilar-Robledo, 2001).

Despite this loss of forest cover in the past, there are few studies and little new quantifiable information on the deforestation rate and other changes in land use and land cover that have occurred in the Huasteca region (Reyes et al., 2006). The Huasteca is located between the Nearctic and Neotropic regions, which are both rich in biodiversity (Mittermeier and Goettsch, 1992). It is therefore very important to conserve its remnant of vegetation in order to protect the biodiversity, and to assure the livelihood of the people as well as all the benefits and services that this region provides.

The timely and precise evaluation of patterns pertaining to land use and land cover change "deforestation" allows understanding how regeneration, succession and degradation processes work in woodland ecosystem (Márquez-Linares et al. 2005). Hence, by evaluating these patterns, this study will contribute to the development of forest management, conservation and restoration strategies in an area affected by human-induced activities.

For these reasons, the main ***objective*** of this paper was to evaluate the deforestation rates in the Huasteca region of Mexico.

MATERIAL AND METHODS

Study area

The Huasteca region is divided into different political and administrative entities, each of which is named according to the state of the Mexican Republic to which it belongs. This is how the Huasteca is constituted by the Huasteca Hidalguense, Potosina, Tamaulipeca, Veracruzana, Poblana and Queretana (Figure 1). The region is generally characterized by sharing a culture and vegetation types with similar characteristics, and the area is located between 22° 16' 00" Northern Latitude and 98° 30' 00" Western Longitude. It covers approximately 65,675.85 km^2 with a population over three millions of inhabitants (CONABIO, 2012).

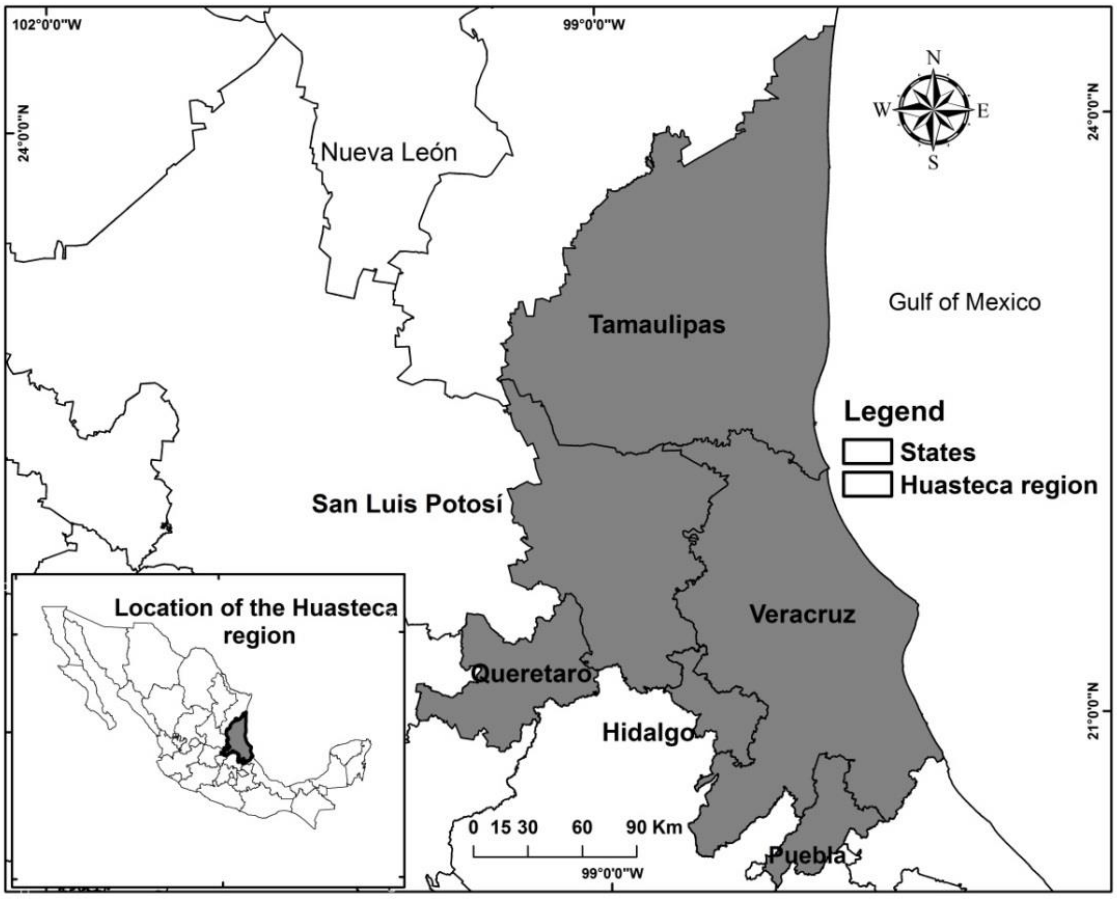

Figure 1. Location of the study area: Huasteca region of Mexico.

Preparation of the data base

The methodological approach was based on the use of a Geographical Information System, which allowed analyzing changes in land use and land cover with a reasonable degree of effectiveness (Klemas, 2001; Velazquez et al. 2002; Berberoglu and Akin, 2009, Weckmüller et al. 2013; Peralta-Rivero et al. 2013). This method made it possible to collect, to structure and to analyze important spatial information for the management of tropical areas (Green et al. 1996; Klemas, 2001).

In order to analyze the land use-land cover change and deforestation processes, many research projects that deal with large areas have used cartography from official sources (Velázquez et al. 2002; Rosete-Vergés et al. 2009; Miranda-Aragón et al. 2013). In the case of the Huasteca Region, the data base for land use and vegetation was used corresponding to series I (t_1) (1976), series II (t_2) (1993), series III (t_3) (2002), series IV (t_4) (2007) and series V (2011) on a scale of 1:250,000. It was provided by the directorate general for research on ecological management and ecosystem conservation of the National Institute of Ecology and the National Institute for Statistics and Geography (INEGI) which had generated and carried out a process of data validation (INEGI, 2000, 2003, 2004, 2005, 2011, 2013; Velazquez et al. 2002; Niño and Victoria, 2013; Rosete et al. 2014) (Table 1).

Table 1. Comparison table of methods and inputs used for mapping land use and land cover in the Huasteca region, scale 1:250,000.

Event	Source of spatial data	Spatial resolution	Methodology	Data of field data
Series I (t_1 1976)	Aerial Photography (years 1986-1986), scale 1:50,000 and 1:80,000	Grain emulsion, scale flight	Analog technology. Optical-mechanical equipment. Transferred to digital format by scanning and digitizing.	(1968) 1971-1986
Series II (t_2 1993)	Landat TM 5, year 1993	30 m/pixel	Analog technology. Optical-mechanical equipment. Transferred to digital format by scanning and digitizing.	1993-1998
Series III (t_3 2002)	Landsat ETM, year 2002	27.5 and 30 m/pixel	Digital technology: PC platform and software SIG	2002-2004
Series IV (t_4 2007)	SPOT, years 2007 and 2008	10 m/pixel	Digital technology: PC platform and software SIG	2007-2008
Series V (t_5 2011)	Landsat TM and ETM	30 m/pixel	Digital technology. PC platform and software SIG	2011-2014

Source: Velázquez et al., 2002; INEGI, 2003, 2004, 2005, 2011, 2013; Niño and Victoria, 2013; Rosete et al. 2014.

In order to obtain the data base for the study area, maps on land use and land cover were merged and projected on the coordinate system UTM WGS-84. This allowed a better overlap of polygons and made it possible to extract the study area.

The classes of land cover and land use were standardized (Appendix 1) and the following were established: agriculture, water, urban areas, forest, scrubland, other types of vegetation, grassland, rain forest, without vegetation, and secondary vegetation (Figure 2). Standardization of classes consisted of labeling digitized polygons in different mother classes (e.g. forest, pasture, agriculture) so that they could be compared to the different series showed in table one. This was done because the different cartographies (series I to Series V) were developed under various methodologies and classification systems of land use and land cover.

Likewise, the different standardized classes were reclassified as natural covers, non original covers, water and urban areas with the aim to analyze the effect of human-induced activities on the land use and land cover in the region (Figure 2) (Appendix 1).

Analysis of the processes of land use and land cover changes

In order to obtain statistical data and maps on land use and land cover changes standardized and cartography sources were superimposed with reclassified cartography sources from the series t_1, t_2, t_3, t_4 and t_5.

This part of the analysis allowed generating a map that expresses the magnitude as well as the spatial distribution of land cover and land use changes dynamics in the Huasteca region.

In order to describe the dynamics of change in the forest cover, a "deforestation process" model was developed, based on which change rates were calculated according to the equation introduced by the FAO (1996) (equation 1).

$$\delta_n = \left(\frac{S_2}{S_1}\right)^{1/n} - 1 \qquad (1)$$

Where δ is the change rate (in order to express percentage, it has to be multiplied by 100); S1 is the surface on the first date 1; S2 is the surface on the second date 2; and *n* is the number of years between the two points of time.

This rate expresses change in terms of the percentage of the surface at the beginning of each year. The same procedure was used for each of the other standardized classes, in a way that the results reflect all transitions regarding land cover and land use.

Covers that were affected by systematic transitions were distinguished from those where change happened randomly. Dominant marks of change and indications for change were identified as well as gross gains and losses, with the aim to obtain the total change in the respective categories (Pontius et al., 2004). To this end, a cross-tabulation or change matrix was developed by crossing the maps created at a specific time (time 1 and time 2). In the mentioned matrix, the rows represent the categories of the map in time 1 (*T1*) and the columns represent the categories of the map in time 2 (*T2*). In addition, another column was added in order to represent the deforestation rate or land use and land cover change for the different classes (Table 2).

Finally, to estimate the areas that were subject to the natural regeneration of vegetation (1976-2011), the covers which had reached a primary forest stratum were quantified and mapped (Table 3).

Table 2. Cross-tabulation matrix for two maps from different dates.

	Time 2							
Time 1	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1		*Class 1*	*Class 2*	……	*Class n*	*Total* T_1	*Loss* (L_{ij})	*Loss rate*
2	*Class 1*	P_{11}	P_{12}	……	P_{1n}	P_{1+}	$P_{1+} - P_{11}$	%
3	*Class 2*	P_{21}	P_{22}	……	P_{2n}	P_{2+}	$P_{2+} - P_{22}$	%
4	……	……	……	……	……	……	……..	%
5	*Class n*	P_{n1}	P_{n2}	……	P_{nn}	P_{n+}	$P_{n+} - P_{nn}$	%
6	*Total* T_2	P_{+1}	P_{+2}	……	P_{+n}	*P*		
7	*Gain* (G_{ij})	$P_{+1} - P_{11}$	$P_{+2} - P_{22}$	……	$P_{+n} - P_{nn}$			

Source: based on Pontius et al., 2004 and FAO, 1996.

Table 3. Examples of the dynamic of land use and land cover change and the identification of natural regeneration and deforestation in the Huasteca Region.

Series I (1976)	Series II (1993)	Series III (2002)	Series IV (2007)	Series V (2011)	Process	Changes in land covers
Secondary vegetation	Secondary vegetation	Secondary vegetation	Forest	Forest	Natural regeneration	Non-original land cover that changed to natural land cover 2002-2007
Pasture	Secondary vegetation	Secondary vegetation	Secondary vegetation	Rain forest	Natural regeneration	Non-original land cover that changed to natural land cover 2007-2012
Forest	Forest	Forest	Agriculture	Pasture	Deforested	Natural land cover that changed to non-original land cover 2002-2007
Rain forest	Agriculture	Pasture	Pasture	Urban area	Deforested	Natural land cover that changed to non-original land cover 1976-1993
Secondary vegetation	Secondary vegetation	Pasture	Pasture	Agriculture	Under human induced activities	Non-original land cover maintained between 1976-2011

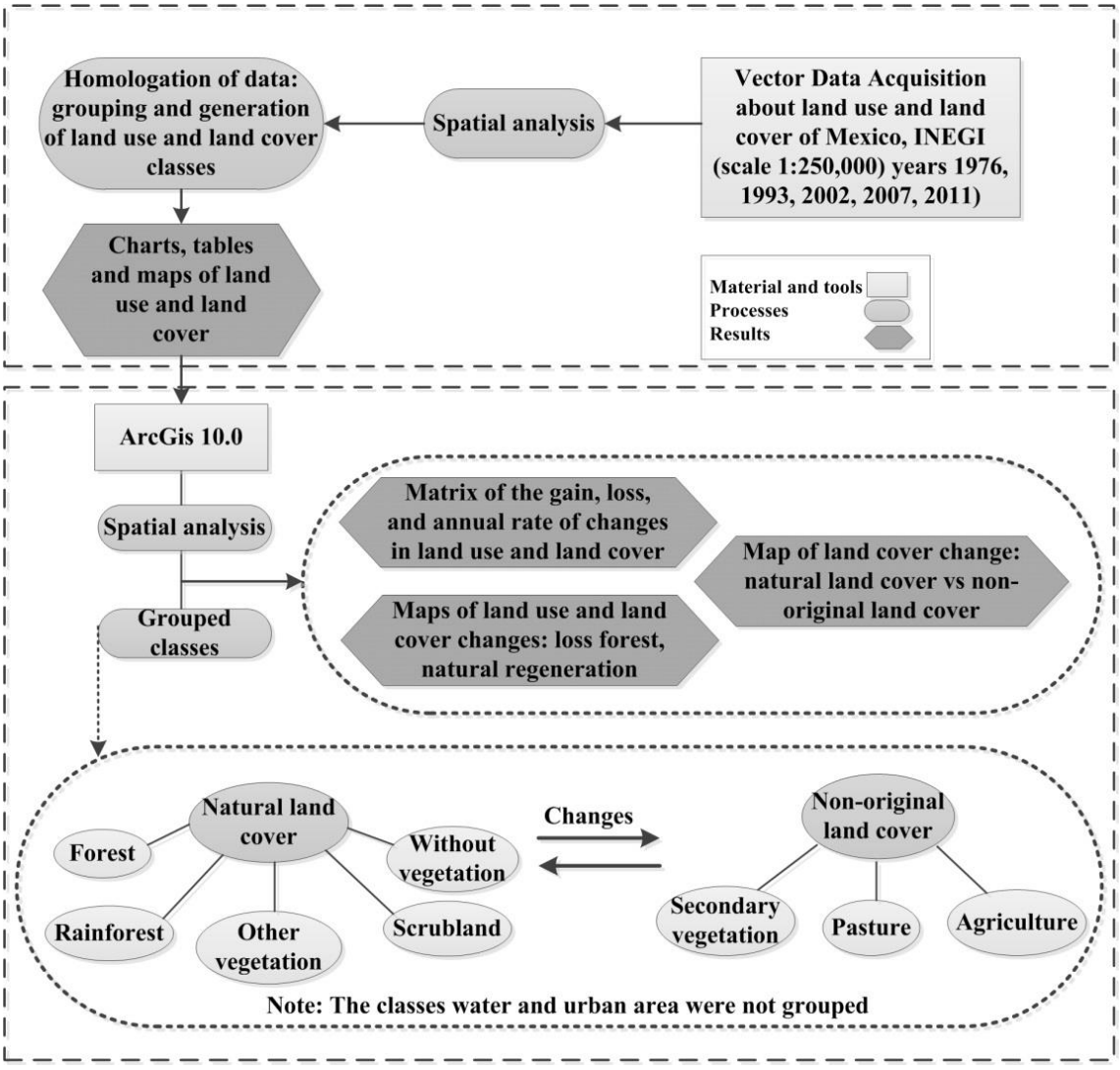

Figure 2. Flowchart of the stages developed in the analysis of changes in land cover and land use.

RESULTS

Land use and land cover

The dynamics of land use and land cover in the Huasteca region can be reconstructed for a timeframe of 35 years (Appendix 2) (Figure 3 and Figure 4), based on the analysis of the obtained information. Table 3 indicates that the biggest areas that were mapped and quantified correspond to agriculture and pasture, representing approximately 60% of the surface of the Huasteca Region in the year 2011. It can be observed that the share of agricultural land has increased continuously by almost 50% over the past 35 years (1976-2011). In the case of pasture, this class had the highest surface until 1993, but in the last period (1993-2011) it has been decreasing its area in small proportions (Figure 3).

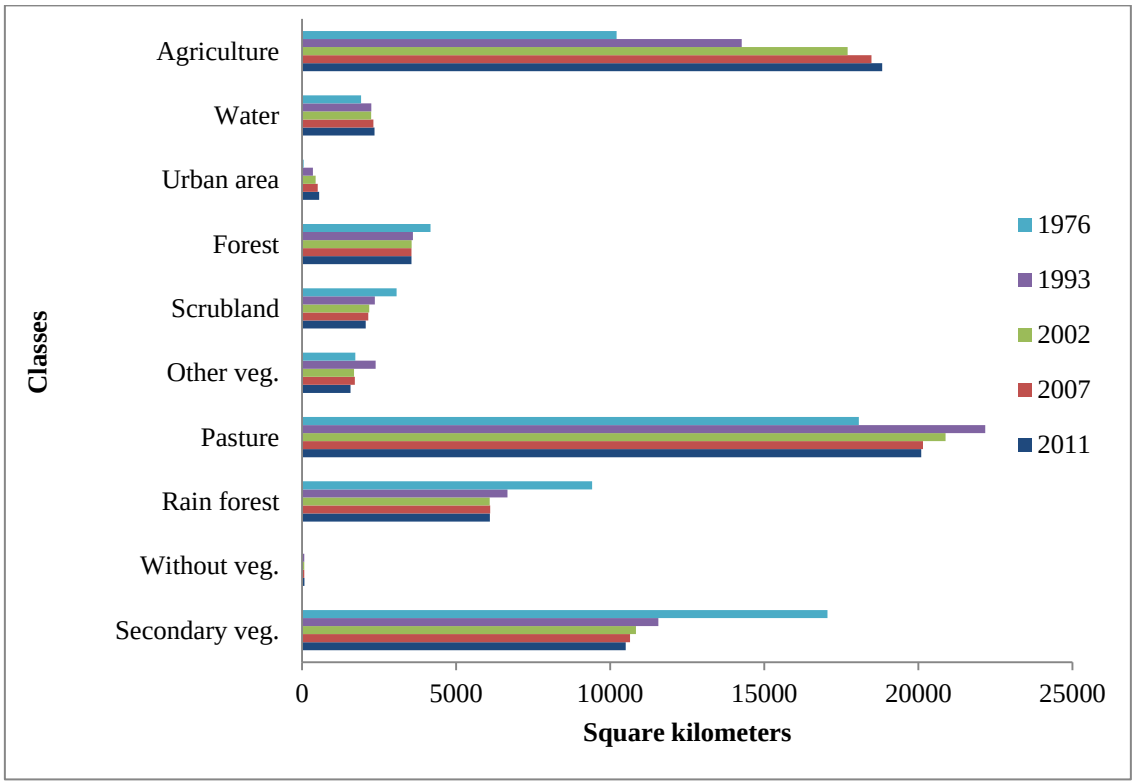

Figure 3. Quantification of the areas according to the class and the year of classification (1976, 1993, 2002, 2007, 2011).

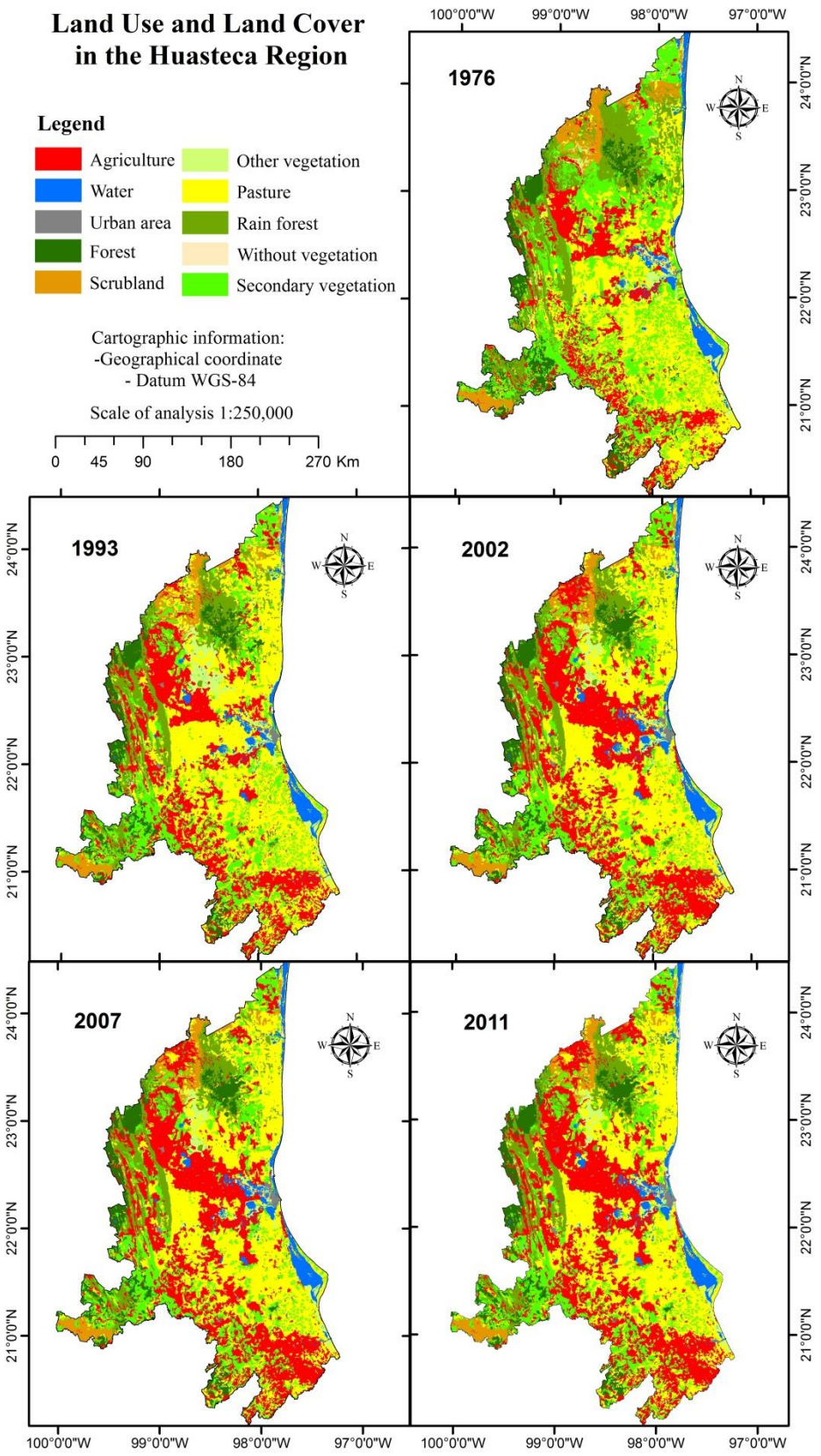

Figure 4. Land use and land cover in the Huasteca region (1976-2011).

Changes in land use and land cover

According to the calculations developed, the most reliable statistical data for the analysis of changes in land use and land cover for the years of study corresponds to data on the forest cover, while the least reliable data refers to water and urban areas which presented inconsistencies in the crossing among the dates of different years. Nonetheless, reasonable evidence of LULCC was found when crossing t_1-t_2, t_2-t_3, t_3-t_4 and t_4-t_5, while also taking account of the particular dynamics of the ecosystems that had been analyzed.

The main changes occurred between t_1-t_2 were the increase in agriculture (1.99%) as well as the high change in the deforestation rate of forest (−0.86%) and rain forests −2.01%. Here, must be noted that there were high rates of lost vegetation, and a considerable increase of the human-induced activities. Furthermore, urban areas increased by 11.82% over the same time period, while areas without vegetation increased by 56.03 km^2 despite the fact that their growth rate was merely 6.33% (Figure 5 and Figure 6) (Appendix 3).

Between 1993 and 2002 (t_2-t_3), most classes of land cover and land use suffered from losses, except for agriculture, water and urban areas. The greatest loss of forest cover was registered for the categories "other types of vegetation" (−3.78%) and "rain forest" (−1.41%), (Figure 5 and Figure 6) (Appendix 4).

Among 2002 and 2007 (t_3-t_4), the loss and gain rates of land use and land cover were much smaller than for the previous periods. A gain could be observed for the category rain forest and other vegetation with 249.55 km^2 and 236.55 km^2 respectively. Furthermore, urban areas increased annually by 3.01%, and agriculture by 0.86%, (Figure 5 and Figure 6) (Appendix 5).

Finally, between 2007 and 2011 (t_4-t_5) the class that suffered changes was other vegetation with a loss rate of −2.13%. In the case of the rain forest, there was a rate of deforestation of −0.05% and for forest a positive rate of 0.02%. (Figure 5 and Figure 6) (Appendix 6).

It must be noted that in the last two periods of analysis (t_3-t_4 and t_4-t_5) the deforestation rate for the main classes of forest vegetation "forest and rain forest" was decreasing. The loss of forest cover between 1976 and 2011 amounted to 1,324.9 km^2 for forests and 4,545.71 km^2 for rain forests, while the natural regeneration of non-forest covers to forest covers made up 731.11 km^2 for forests and 1,252.72 km^2 for rain forests (Appendix 3, 4, 5, 6).

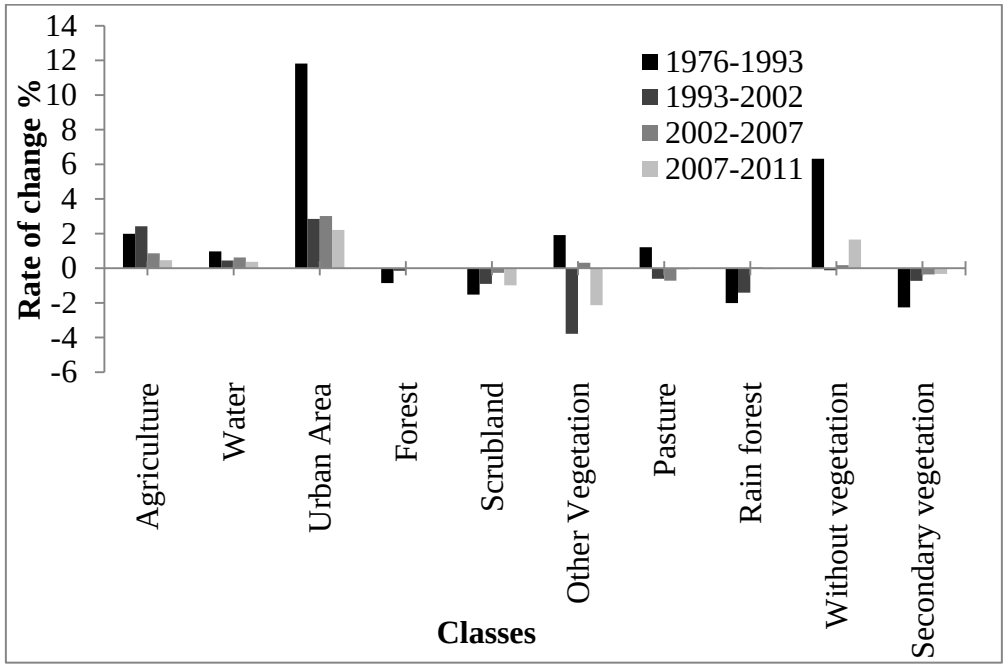

Figure 5. Annual rate of land cover and land use change in the Huasteca region in different periods.

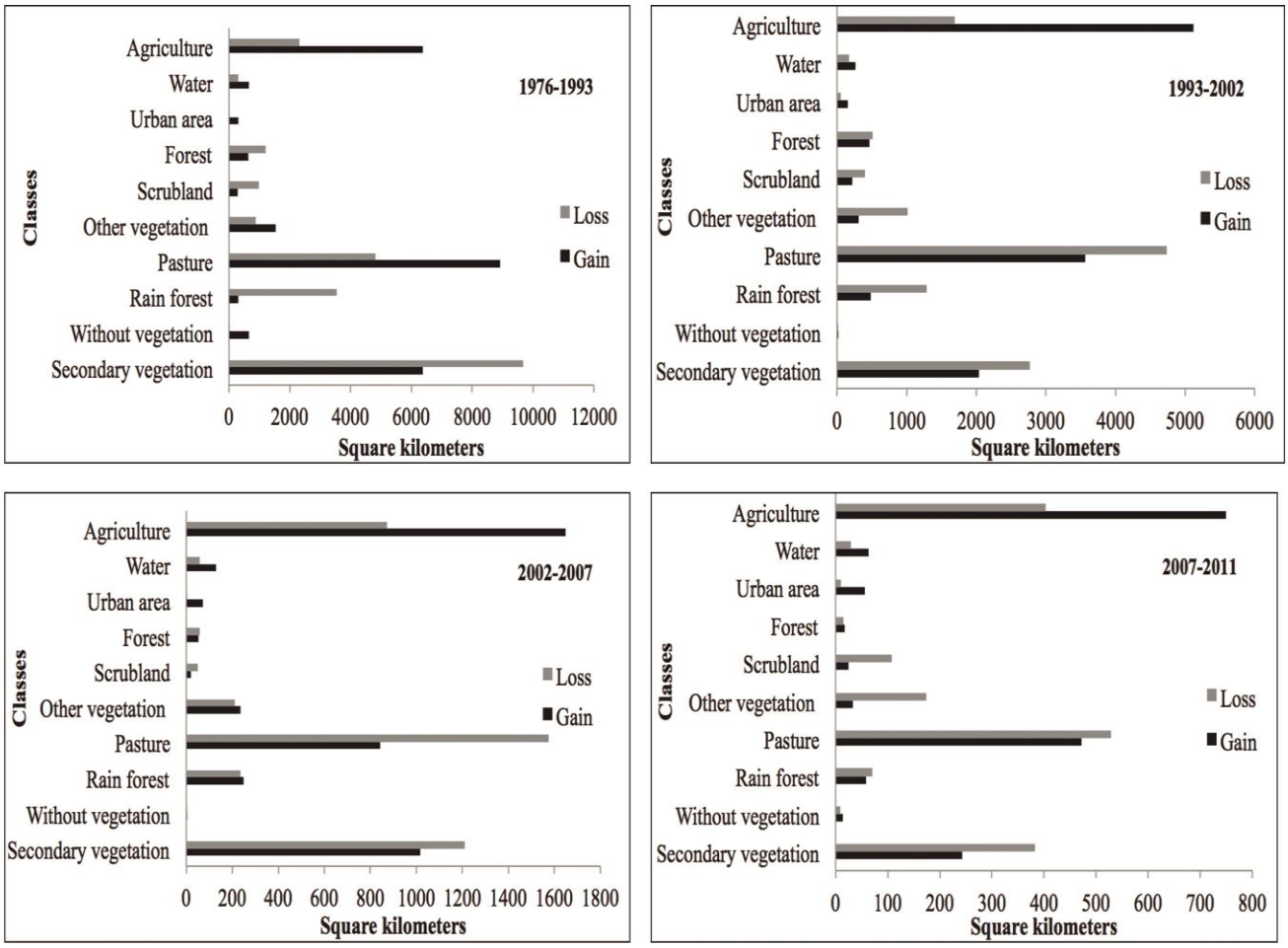

Figure 6. Loss and gain of land use and land cover in the Huasteca region in different periods.

General changes in land cover

By crossing data from four years (1976, 1993, 2002 and 2007), it can be observed that the pressure of human-induced activities on natural land cover (forest, rain forest, other vegetation, scrubland and no vegetation) has increased its surface, translating into an increase of non-original cover (secondary vegetation, pasture and agriculture). Despite this, in 2011, the Huasteca region conserved approximately 11,022.63 km^2 of original land cover representing 16.78% of the surface. Furthermore, the development of total changes in land cover and land use amounted to 17.43%, or 11,446.75 km^2 of the Huasteca region, as shown in detail in (Table 4).

The main changes occurred with regard to natural land covers which transformed into non-original land covers, mostly in the period of time between 1976 and 1993 with 4,874.28 km^2, followed by 2,474.93 km^2 for the period of time between 1993 and 2002, and finally 677.63 km^2 for the period of time between 2002 and 2011. In spite of this loss of natural cover, 2,122.81 km^2 were recovered between 1976 and 2011 taking into account only the non-original land covers (Table 5) (Figure 7 and Figure 8).

The changes from natural covers to non-original land covers represent 12.22% of the surface of the study area, and the changes of non-original land cover to natural land covers make up 3.23%. Other changes that occurred in small proportion were related to the increase and decrease of the urban area and water bodies in the different periods of analysis, and in sum they represent 1.98% (Table 5).

Finally, the data on land use and land cover shows slight imprecision with regard to the transition, which has also occurred in other studies of analysis on land cover and land use change. In this case, the error found of 543.84 km^2 or 0.83% refers mainly to inconsistencies with regard to the original land use classification and inconsistent changes in land use and land cover take into account the individual dynamics of ecosystems and problems of overlap.

Table 4. Evolution of the status and changes in all the grouped and maintained covers in the years 1976, 1993, 2002, 2007 and 2011.

State of the land covers	km^2	%
Natural cover maintained between 1976 and 2011	11,022.63	16.78
Non-original cover maintained between 1976 and 2011	41,143.28	62.65
Urban area maintained between 1976 and 2011	46.94	0.07
Water maintained between 1976 and 2011	1,472.40	2.24
Cover changes between 1976 and 2011	11,446.75	17.43
Error	543.84	0.83
	65,675.85	**100.00**

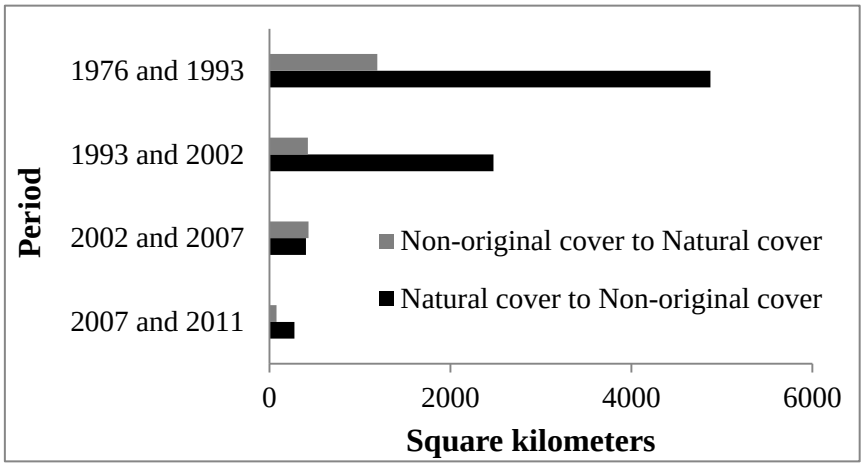

Figure 7. Changes of non-original land cover and natural cover in the Huasteca Region between 1976 and 2011.

Table 5. Changes in land use and land cover of reclassified classes, years 1976, 1993, 2002, 2007 and 2011.

Changes in land covers	km^2	%
Water maintained between 1976 and 2011*	1,472.40	2.24
Water that changed to non-original land cover between 1976-1993	76.24	0.12
Water that changed to non-original land cover between 1993-2002	39.27	0.06
Water that changed to natural land cover between 1976-1993	90.63	0.14
Water that changed to natural land cover between 1993-2002	40.06	0.06
Water that changed to natural land cover between 2007-2011	6.46	0.01
Natural land cover that changed to non-original land cover 1976-1993	4,874.28	7.42
Natural land cover that changed to non-original land cover 1993-2002	2,474.93	3.77
Natural land cover that changed to non-original land cover 2002-2007	402.91	0.61
Natural land cover that changed to non-original land cover 2007-2011	274.92	0.42
Natural land cover that changed to water between 1976-1993	208.18	0.32
Natural land cover that changed to water between 2002-2007	59.69	0.09
Natural land cover that changed to water between 2007-2011	46.94	0.07
Urban area maintained between 1976 and 2011*	26.32	0.04
Natural land cover that changed to urban area between 1976-1993	14.4	0.02
Natural land cover that changed to urban area between 1993-2002	18.41	0.03
Natural land cover that changed to urban area between 2002-2007	2.2	0.00
Natural land cover that changed to urban area between 2007-2011	1.5	0.00
Non-original land cover that changed to water between 1976-1993	234.14	0.36
Non-original land cover that changed to water between 1993-2002	106.01	0.16
Non-original land cover that changed to water between 2002-2007	41.56	0.06
Non-original land cover that changed to water between 2007-2011	4.53	0.01
Non-original land cover that changed to natural land cover 1976-1993	1,191.84	1.81
Non-original land cover that changed to natural land cover 1993-2002	423.15	0.64
Non-original land cover that changed to natural land cover 2002-2007	430.94	0.66
Non-original land cover that changed to natural land cover 2007-2011	76.88	0.12
Non-original land cover that changed to urban area between 1976-1993	210.42	0.32
Non-original land cover that changed to urban area between 1993-2002	6.2	0.01
Non-original land cover that changed to urban area between 2002-2007	62.93	0.10
Non-original land cover that changed to urban area between 2007-2011	47.76	0.07
Non-original land cover maintained between 1976-2011*	41,143.28	62.65
Natural land cover maintained between 1976-2011*	11,022.63	16.78
Error	543.84	0.83
	65,675.85	**100.00**

*** Covers without a change in land use or land cover from 1976 until the year 2011.**

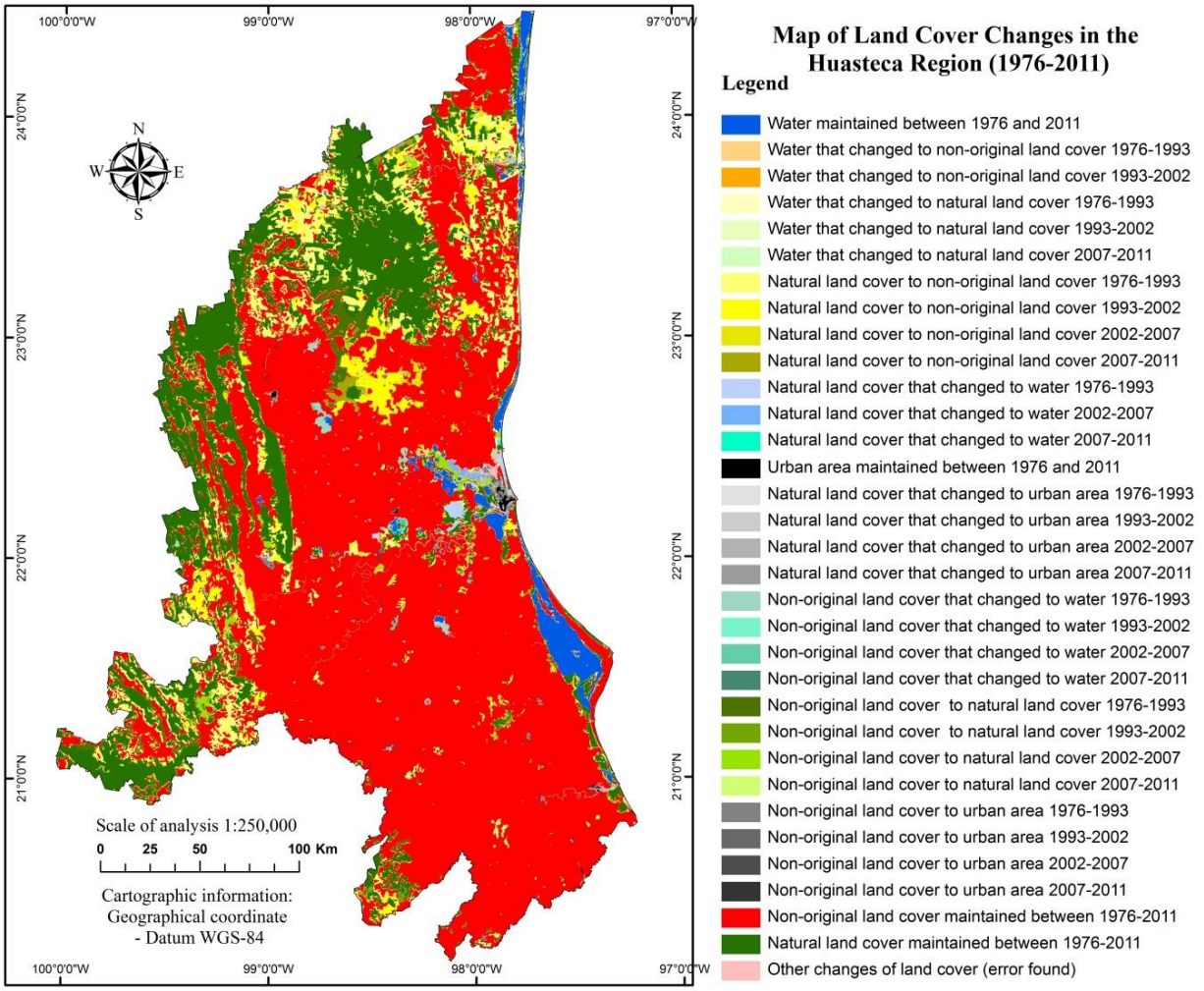

Figure 8. Land covers dynamics of the grouped classes for the Huasteca Region, for the periods 1976-2011.

DISCUSSION

The Huasteca was a region the surface of which was covered by natural land covers with a low impact and grade of transformation in its landscapes (Instituto Nacional de Geografía, 1992a, 1992b). But over time, agricultural modernization and industrialization, the increase of livestock, and the demand for wood and wood derived products had important stake in the considerable increase of land cover types that were induced by humans (Aguilar-Robledo, 2001).

Obtained data demonstrates that for the studied years, forest cover (rain forest, forest and scrubland) in particular reduced its surface, as affirmed by Reyes et al., (2006) and Quinteros (2012).

The highest deforestation rate calculated was −2.01% for the period 1976-1993, and it must be noted that it is higher than the general national deforestation rate for Mexico (−0.25 and −1.02%) between 1976 and 2000 according to Velázquez et al. 2002, and (−0.76%) according to Mas et al., (2009). Only the state of Veracruz has a higher deforestation rate (−2.2%) between 1993 and 2002, and the deforestation rate is generally lower in all other states of the Mexican Republic (Céspedes-Flores and Moreno-Sánchez 2010). Likewise, in accordance with Rosete-Vergés et al. (2014), the deforestation rate for rain forest and forest in Mexico had been -0.41% and -0.08% respectively between 1976 and 2007, and it is lower than

our findings for the first two periods of analysis (1976-1993 and 1993-2002), but it is almost the same in the last two periods of analysis (2002-2007 and 2007-2011). In the two last periods of analysis, it was found that the forest cover reduced its deforestation rate, a tendency that was calculated for all the republic of Mexico by Mas et al., (2009).

Some of the consequences of deforestation in the Huasteca region are related to government policies. In the decade of seventies the Mexican government for instance launched the irrigation project "Pujal Coy", which caused the transformation of large areas of forests to other uses in a large part of the Huasteca. According to Reyes et al. (2006), deforestation rates reached 5% for forests and up to 11% for secondary vegetation between 1976 and 2000. Another project with similar characteristics was the National Clear Program, better known as PRONADE, between 1972 and 1983. It was a Mexican government program intended to cut a total of 24,598,797 hectares, (12% of the country) (mostly evergreen and deciduous forest) in order to convert the land into pasture for cattle (Moreno, 2011). Both projects included extensive areas of the Huasteca region (Aguilar-Robledo 1992).

Yet, until 1976 the Huasteca region conserved approximately 34.21% of its original land cover. Furthermore, the development of total changes in land cover and land use amounted to 17.43% or 11,446.75 km^2 of the area and the main remnant are located in the high land (Sierra Madre Oriental) of this region (16.78% or 11,022.63 km^2). However, although forest remnants are located on high lands, this is not a guarantee for their conservation. Sahagún (2011) argues that between 1989 and 2005 deforestation rates for rain forest in the Sierra Madre Oriental were -0.42 % higher than the national average previously discussed. Also, Ibarra (2008) demonstrates that in the "Sierra del Abra de Tanchipa", a natural area protected in the Huasteca region was modified and deteriorated by induced-human activities between 1973 and 2005.

Based on this discussion, it needs to be emphasized that the Huasteca region is the bridge between the Nearctic and Neotropic regions rich in biodiversity, and many actions must be undertaken to conserve this area, in order to assure the survival of biodiversity, the livelihood of the people and all direct and indirect benefits and services that it provides.

CONCLUSIONS

It can be concluded that the mapping of changes in land use and land cover for the period of study (1976-2011) using techniques of Geographic Informatics System are adequate for the evaluation and the analysis of the changes that have occurred in the Huasteca region, since they were able to identify phenomena of deforestation and losses of natural land covers.

Also, techniques of Geographic Informatics System recognize the errors in the classification of land use and land cover, product of different methodologies used in the production of the original cartography, and the error rate found regarding changes in land use was of 0.83% or 543.84 km^2.

The analysis carried out based on a cross-tabulation matrix demonstrated that in particular agriculture and pasture caused the modification of the biophysical landscape of the Huasteca over the period of time from 1976 until 1993. Deforestation rates for rain forests, forests, scrublands and other types of vegetation were also higher than the national deforestation rates reported for México, even though for the period of time between 2002 and 2011 a backward trend could be observed.

The analysis which measured the land cover change (natural land cover and non-original land cover), indicated that non-original coverage increased by 8,027.04 km^2, and natural land cover only recovered 2,122.81 km^2 in the same period of 35 years.

Furthermore, Geographical System Information showed that 62.65% (41,143.28 km^2) of the surface of the Huasteca region had been modified by human activities before the year 1976, and from 1976 until 2011 changes affected 17.43% (11,446.75 km^2) of the study area.

It was furthermore demonstrated that the loss of forest cover in the Huasteca between 1976 and 2011 amounted to 1,324.9 km^2 for forests and 4,545.71 km^2 for rain forests, while the natural regeneration of non-forest covers to forest covers made up 731.11 km^2 for forests and 1,252.72 km^2 for rain forests. In other words, only 33.79 % of the area affected by deforestation has been recovered by natural regeneration, and the rest has been maintained for other uses.

REFERENCES

Aguilar-Robledo, M. 1992. La reganaderización del Pujal-Coy 1a. y 2a. Etapa (Los avatares de un proyecto regional). pp. 56-82. En: L. Fuentes (Ed). Cambios de uso de suelo agrícola en México. Instituto de Geografía, UNAM, pp.211.

Aguilar-Robledo, M. 2001. Ganadería, tenencia de la tierra, e impacto ambiental en la Huasteca Potosina: los años de la Colonia. En L. Hernández (Ed.). Historia ambiental de la ganadería en México. Instituto de Ecología-Institut de Recherche pour le Développement. Xalapa, pp. 9-24.

Algara, M. 2009. Propuesta metodológica para medir el impacto del fenómeno de la sequía en la Huasteca Potosina y propuesta general de manejo. Tesis de doctorado en ciencias ambientales. Universidad Autónoma de San Luis Potosí, San Luis Potosí, pp. 158.

Berberoglu, S. and A. Akin. 2009. Assessing different remote sensing techniques to detect land use/cover changes in the eastern Mediterranean. International Journal of Applied Earth Observation and Geoinformation, 11, 46-53.

http://dx.doi.org/10.1016/j.jag.2008.06.002

Castillo-Santiago, M. A., A. Hellier, R. Tipper and B.H.J. De Jong. 2007. Carbon emissions from land use change: An analysis of causal factors in Chiapas, Mexico. Mitigation and Adaptation Strategies for Global Change, 12, 1213-1235.

http://dx.doi.org/10.1007/s11027-006-9060-7

Céspedes-Flores, S. and E. Moreno-Sánchez. 2010. Estimación del valor de pérdida de recurso forestal y su relación con la deforestación en las entidades federativas de México. Investigación Ambiental, 2, 5-13.

CONABIO, 2012. Distribución de la población en México por municipio, 2010, escala: 1:250000. Comisión Nacional Para el Conocimiento y Uso de la Biodiversidad. México D.F.: Datos estadísticos del 2010, del Instituto Nacional de Estadística y Geografía (INEGI). Dirzo, R., & García, M. (1992). Rates of deforestation in Los Tuxtlas, a neotropical area in southeast Mexico. Conservation Biology, 6, 84-90.

Dirzo, R. and M. García. 1992. Rates of deforestation in Los Tuxtlas, a neotropical area in southeast Mexico. Conservation Biology, 6, 84-90.

FAO, 1996. Forest resources assessment 1990. Survey of tropical forest cover and study of change processes. Roma: FAO, pp.154.

Green, E. P., P. J. Mumby, A. J. Edwards and C. D. Clark. 1996. A review of remote sensing for the assessment and management of tropical coastal resources. Coastal Management, 24, 1-40. http://dx.doi.org/10.1080/08920759609362279

Ibarra Zapata, E. 2008. "Análisis Geográfico para la Conservación de la Naturaleza. Estudio de Caso Área Natural Protegida Reserva de la Biosfera Sierra Abra de Tanchipa, Ciudad Valles y Tamuin, San Luis Potosí". Tesis de licenciatura en geografía, Coordinación de Ciencias Sociales y Humanidades, UASLP. pp. 131.

Instituto Nacional de Geografía, 1992a. Influencia Humana sobre el medio ambiente uno. Época precolonial, época colonial, época de porfiriato. Ciudad de México. Mapas a escala 1:8,000,000.

Instituto Nacional de Geografía, 1992b. Influencia Humana sobre el medio ambiente dos. Época actual. Ciudad de México. Mapas a escala 1:4,000,000.

INEGI, 2000. Diccionario de datos de uso de suelo y vegetación: Escala 1:250,000 (vectorial). Serie I. DGG-INEGI. México.

INEGI, 2003. Carta de Uso del Suelo y Vegetación Serie I (1968-1986), escala 1:250,000. Instituto Nacional de Estadística y Geografía. México.

INEGI, 2004. Carta de Uso del Suelo y Vegetación Serie II (Reestructurada) (1993), escala 1:250,000. Instituto Nacional de Estadística y Geografía. México.

INEGI, 2005. Carta de Uso del Suelo y Vegetación Serie III (2002), escala 1:250,000 (Continuo Nacional). Instituto Nacional de Estadística y Geografía. México.

INEGI, 2007. Carta de Uso del Suelo y Vegetación Serie IV (2007), escala 1:250,000. Instituto Nacional de Estadística y Geografía. México.

INEGI, 2013. Carta de Uso del Suelo y Vegetación, Serie V (2011), escala 1:250,000. Instituto Nacional de Estadística y Geografía. México.

Klemas, V. 2001. Remote sensing of landscape-level coastal environmental indicators. Environmental Management, 27, 47-57.

López Blanco, J. 2005. Sistemas de información geográfica en estudios de geomorfología ambiental y recursos naturales. Ciudad de México: Universidad Nacional Autónoma de México.

Mas, J. F., A. Velázquez and S. Couturier. 2009. La evaluación de los cambios de cobertura/uso del suelo en la República Mexicana. Investigación Ambiental, 1, 23-39.

Márquez-Linares, M. A., E. J. Treviño and E. Jurado. 2005. Reemplazo de áreas arboladas por chaparrales y comunidades herbáceas en el período 1970-2000 en una Microcuenca de Durango, México. Investigaciones Geográficas, 58, 54-65.

Miranda-Aragón, L., E. J. Treviño-Garza, J. Jiménez-Pérez, O. A. Aguirre-Calderón, M. A. González-Tagle, M. Pompa-García and C. A. Aguirre-Salado. 2013. Tasas de deforestación en San Luis Potosí, México (1993-2007). Revista Chapingo Serie Ciencias Forestales y del Ambiente, 2, 201-215.

http://dx.doi.org/10.5154/r.rchscfa.2011.06.044

Mittermeier, R. and C. Goettsch. 1992. La importancia de la diversidad biológica de México. Pp. 63-73. En: J. Sarukhán & Dirzo R. (compiladores). México ante los retos de la biodiversidad. CONABIO. Ciudad de México.

Moreno, A. 2011. Efectos ambientales del Programa Nacional de Desmonte, México, 1972-1982. Tesis de maestría en ciencias ambientales, Universidad Autónoma de San Luis Potosí. San Luis Potosí. pp. 119.

Niño M. and E. Victoria. 2013. Información de usos del suelo y vegetación escala 1:250,000, SERIE V (Conjunto Nacional).

http://langif.uaslp.mx/selper/documentos/CD_SELPER_2013/MEMORIAS_SELPER_PDF/Estudios_Tematicos/ID_008.pdf

Pacheco, P., E. Ormachea, P. Cronkleton, M. Albornoz, and L. Paye. 2009. Trayectorias y tendencias de la economía extractiva en el norte amazónico de Bolivia. La Paz: CIFOR-CEDLA, pp. 52.

Peralta-Rivero, C., C. Contreras, M. G. Galindo, J. C. Torrico and V. A. Vos. 2013. Cambios de Uso del Suelo, y Proyectos Forestales MDL y REDD en Riberalta, Amazonía Boliviana. CienciAgro, 4, 403-420.

Pontius, R. G., E. Shusas and M. McEachern. 2004. Detecting important categorical land changes while accounting for persistence. Agriculture, Ecosystems and Environment, 101, 251-268. http://dx.doi.org/10.1016/j.agee.2003.09.008

Quinteros, J. 2012. Estudio ambiental y social comparativo del bosque húmedo en base al cambio de uso de suelo entre la Huasteca Potosina, México y la Mata Atlántica, rio de janeiro, Brasil. Tesis de maestría en ciencias ambientales, Universidad Autónoma de San Luis Potosí. San Luis Potosí. pp. 168.

Reyes, H., R. M. Aguilar, R. J. Aguirre y I. Trejo (2006), "Cambios en la cubierta vegetal y uso del suelo en el área del proyecto Pujal-Coy, San Luis Potosí, México. 1973-2000", Investigaciones Geográficas, 59, 26-42.

Ricker, M. 2010. La cobertura forestal y la problemática de la deforestación en México (pp. 1-6). Mexico City: Instituto de Biología. Universidad Nacional Autónoma de México.file:///J|/MARTIN%20FILES/MARTIN'S%20PDFS/PÁGINA%20AGOSTO%202010/webCoverForDefor.htm

Rosete-Vergés, F., J. L. Pérez-Damián And G. Bocco. 2009. Contribución al análisis de cambios de uso del suelo y vegetación (1978-2000) en la peninsula de Baja California, México. Investigación Ambiental, Ciencia y Política Pública, 1, 70-82.

Rosete-Vergés, F., J. L. Pérez-Damián, M. Villalobos-Delgado, E. N. Navarro-Salas, E. Salinas-Chávez y R. Remond-Noa. 2014. El avance de la deforestación en México 1976-2007. Madera y Bosques, 20, 21-35.

Sahagún, F. J. 2012. Dinámica espacio-temporal de las transformaciones en la cobertura vegetal y en el cambio de uso de suelo en la sierra madre oriental de San Luis Potosí y sus efectos potenciales sobre la distribución de la avifauna. Tesis de maestría en ciencias ambientales, Universidad Autónoma de San Luis Potosí. San Luis Potosí. pp. 178.

Velázquez, A., J. F. Mas, J. R. Díaz, R. Mayorga, P. C. Alcántara, R. Castro, T. Fernández, G. Bocco, E. Ezcurra, and J. L. Palacio. 2002. Patrones y tasas de cambio de uso de suelo en México. Gaceta Ecológica, 62, 21-37.

Vitousek, P. M., H. A. Mooney, J. Lubchenco and J. M. Melillo. 1997. "Human domination of Earth´s ecosystems", Science, 277, 494-499.

Weckmüller, R., N. C. Slovinscky e R. Vicens. 2013. Análise multitemporal como subsídio à identificação da trajetória evolutiva do uso e cobertura da terra no Corredor Ecológico do Muriqui/RJ. Revista Brasileria de Cartografia 65(3): 467-477.

Zepeda, C., X. A. Nemiga, A. Lot and D. Madrigal. 2012. Análisis del cambio de uso de suelo en las ciénagas de Lerma (1973-2008) y su impacto en la vegetación acuática. Investigaciones geográficas, 58, 54-65.

APPENDIX

Appendix 1. Classification and reclassification of land use and land cover classes employed in the analysis of land use and land cover changes for the Huasteca region.

Reclassification of covers	Original Land use and land cover classes	Status covers
1. Agriculture	Moisture agriculture	Non-original land cover
	Irrigated agriculture	
	Seasonal agriculture	
2. Water	Water bodies	Water
	Aquaculture	Non-original land cover
3. Urban area	Urban zone	Urban area
	Human settlements	
4. Forest	Oak forest	Natural land cover
	Oak-pine forest	
	Pine forest	
	Pine-oak forest	
	Tascate forest	
	Cloud forest	
5. Scrubland	Crasicaule scrubland	Natural land cover
	Microphyll scrubland	
	Short xerophitic scrunland	
	Tamaulipan thornscrub	
	Submontane scrubland	
6. Other vegetation	Chaparral	Natural land cover
	Mezquital	
	Palmar	
	Costal dunes vegetation	
	Gallery vegetation	
	Mesquite forest	
	Native palmar	
	Mangroves	
	Gallery rain forest	
	Gallery forest	
	Floodable	
	Halophilous vegetation	
	Reed beds	

Continuation Appendix

Reclassification of covers	Original Land use and land cover classes	Status covers
7. Pasture	Cultivated pasture	Non-original land cover
	Halophytic pasture	Natural land cover
	Induced pasture	Non-original land cover
8. Rain forest	High moist evergreen forest	Natural land cover
	High semi- evergreen forest	
	Low dry forest	
	Low thorny dry forest	
	Semi-deciduous low dry forest	
	Medium semi-deciduous forest	
	Medium semi-evergreen forest	
9. Without vegetation	No vegetation apparent	Natural land cover
10. Secondary vegetation	Cultivated forest	Non-original land cover
	Induced palmar	
	Forty five types of secondary vegetation (tree, shrub and herbaceous)	

Appendix 2. Quantification of the areas according to class and year of classification.

	1976	1993	2002	2007	2011	1976	1993	2002	2007	2011
Classes	**km^2**	**km^2**	**km^2**	**km^2**	**km^2**	**%**	**%**	**%**	**%**	**%**
Agriculture	10,206.76	14,265.25	17,701.80	18,477.82	18,823.19	15.54	21.72	26.95	28.13	28.66
Water	1,911.56	2.245.01	2,242.83	2,313.97	2,348.13	2.91	3.42	3.42	3.52	3.58
Urban area	51.39	351.03	438.64	508.87	555.66	0.08	0.53	0.67	0.77	0.85
Forest	4,165.14	3,598.73	3,553.75	3,548.43	3,550.75	6.34	5.48	5.41	5.40	5.41
Scrubland	3,064.50	2,360.94	2,177.06	2,148.29	2,065.26	4.67	3.59	3.31	3.27	3.14
Other vegetation	1,726.66	2,385.14	1,686.28	1,713.34	1,571.82	2.63	3.63	2.57	2.61	2.39
Pasture	18,067.40	22,169.03	20,882.93	20,148.85	20,092.07	27.51	33.76	31.80	30.68	30.59
Rain forest	9,410.23	6,665.79	6,088.87	6,102.92	6,091.66	14.33	10.15	9.27	9.29	9.28
Without vegetation	25.51	72.36	71.24	71.90	76.77	0.04	0.11	0.11	0.11	0.12
Secondary vegetation	17,046.70	11,562.57	10,832.44	10,641.45	10,500.53	25.96	17.61	16.49	16.20	15.99
	65,675.85	**65,675.85**	**65,675.85**	**65,675.85**	**65,675.85**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Appendix 3. Cross-tabulation matrix or change matrix between t1 and t2 (data in km2).

	1993												
1976	Agriculture	Water	Urban area	Forest	Scrubland	Other vegetation	Pasture	Rain forest	Without vegetation	Secondary vegetation	Total 1976	Loss	Loss rate (%)
Agriculture	**7,901.13**	98.60	103.12	94.48	30.49	362.92	761.07	136.26	3.65	715.04	***10,206.76***	2,305.63	1.99
Water	37.85	**1,602.29**	0.00	0.14	6.30	154.86	70.37	4.82	22.76	12.17	***1,911.57***	309.28	0.97
Urban area	0.58	1.28	**48.33**	0	0	0.31	0.87	0	0.01	0	***51.39***	3.06	11.82
Forest	168.69	0.71	1.23	**2,968.13**	27.54	9.57	166.44	138.25	0	684.60	***4,165.14***	1,197.01	-0.86
Scrubland	136.14	7.37	1.71	5.43	**2,077.65**	13.28	634.57	49.94	0	138.40	***3,064.50***	986.85	-1.52
Other vegetation	166.78	259.82	8.02	5.11	24.93	**843.03**	311.93	41.69	14.41	50.94	***1,726.67***	883.63	1.92
Pasture	2,238.15	149.35	106.30	58.48	18.91	236.94	**13,259.08**	155.47	5.11	1,839.61	***18,067.40***	4,808.32	1.21
Rain forest	684.77	25.30	9.30	187.12	62.40	50.51	1,774.82	**5874.45**	2.02	739.55	***9,410.23***	3,535.78	-2.01
Without vegetation	0	2.61	0.22	0	0	3.49	0.68	0	**16.34**	2.16	***25.51***	9.17	6.33
Secondary vegetation	2,931.15	105.61	64.87	279.85	112.72	710.22	5,189.22	264.90	8.07	**7,380.08**	***17,046.69***	9,666.61	-2.26
Total 1993	***14,265.25***	***2,252.95***	***343.09***	***3,598.73***	***2,360.94***	***2,385.14***	***22,169.03***	***6,665.79***	***72.37***	***11,562.56***			
Gain	6,364.12	650.66	294.76	630.60	283.28	1,542.11	8,909.96	791.34	56.03	4,182.48			

Appendix 4. Cross-tabulation matrix or change matrix between t_2 and t_3 (data in km^2).

	2002												
1993	Agriculture	Water	Urban area	Forest	Scrubland	Other vegetation	Pasture	Rain forest	Without vegetation	Secondary vegetation	Total 1993	Loss	Loss rate (%)
Agriculture	**12,579.24**	49.44	45.32	67.39	41.76	81.43	807.98	154.83	0.03	437.85	***14,265.25***	1,686.01	2.43
Water	60.94	**2,071.78**	0.00	0.81	2.85	77.61	0.00	0.00	10.26	20.78	***2,245.01***	173.24	0.45
Urban area	43.30	6.81	**295.17**	0.00	0.42	2.36	0.00	0.00	0.00	2.96	***351.03***	55.85	2.85
Forest	70.40	0.80	1.32	**3,088.95**	5.91	2.75	114.60	77.81	0.00	236.19	***3,598.73***	509.78	-0.14
Scrubland	140.56	8.35	0.51	4.35	**1,959.26**	24.84	136.88	53.92	0.00	32.27	***2,360.94***	401.68	-0.90
Other vegetation	132.94	74.12	9.72	1.42	16.85	**1,374.88**	555.19	66.76	2.80	150.46	***2,385.14***	1,010.27	-3.78
Pasture	3,547.92	94.99	60.44	68.45	84.87	81.43	**17,436.16**	0.00	0.96	793.81	***22,169.03***	4,732.87	-0.60
Rain forest	232.08	9.66	13.17	199.76	35.59	14.17	420.05	**5,382.64**	1.15	357.51	***6,665.79***	1,283.15	-1.41
Without vegetation	0.00	3.43	2.05	0.00	0.00	4.72	2.43	0.00	**54.40**	5.34	***72.36***	17.96	-0.12
Secondary vegetation	894.40	17.94	24.27	122.08	29.56	22.11	1,523.69	131.24	2.02	**8,795.27**	***11,562.57***	2,767.31	-0.72
Total 2002	***17,701.79***	***2,337.30***	***451.98***	***3,553.21***	***2,177.06***	***1,686.29***	***20,996.98***	***5867.19***	***71.61***	***10,832.44***			
Gain	5,122.55	265.53	156.80	464.26	217.80	311.41	3,560.82	484.55	17.21	2,037.17			

Appendix 5. Cross-tabulation matrix or change matrix between t_3 and t_4 (data in km^2).

	2007												
2002	Agriculture	Water	Urban area	Forest	Scrubland	Other vegetation	Pasture	Rain forest	Without vegetation	Secondary vegetation	Total 2002	Loss	Loss rate (%)
Agriculture	**16,829.65**	19.07	32.79	9.47	0.85	24.18	351.08	77.46	0.55	356.71	***17,701.80***	872.15	0.86
Water	1.16	**2,184.40**	0.00	0.00	2.22	46.30	5.81	1.55	0.14	1.26	***2,242.84***	58.44	0.63
Urban area	0.70	0.12	**437.41**	0.02	0.00	0.00	0.36	0.00	0.00	0.03	***438.64***	1.23	3.01
Forest	14.91	0.00	0.00	**3,496.50**	0.57	3.43	19.01	4.08	0.00	15.24	***3,553.75***	57.25	-0.03
Scrubland	12.60	0.11	0.45	0.53	**2,128.25**	0.82	30.71	0.03	0.00	3.56	***2,177.06***	48.82	-0.27
Other vegetation	77.09	71.71	3.02	0.00	0.11	**1,476.80**	25.51	3.83	0.68	27.54	***1,686.29***	209.49	0.32
Pasture	757.71	37.04	26.80	13.74	15.46	143.84	**19,306.69**	55.46	1.49	524.69	***20,882.93***	1,576.24	-0.71
Rain forest	64.79	0.91	0.00	22.36	0.00	0.06	58.45	**5,853.37**	0.61	88.34	***6,088.87***	235.51	0.05
Without vegetation	0.11	0.00	0.00	0.00	0.00	2.80	0.07	0.46	**67.16**	0.64	***71.24***	4.08	0.18
Secondary vegetation	719.22	0.51	8.39	5.82	0.83	15.12	351.16	106.68	1.28	**9,623.43**	***10,832.44***	1,209.00	-0.36
Total 2007	***18,477.93***	***2,313.87***	***508.87***	***3,548.43***	***2,148.29***	***1,713.35***	***2,0148.85***	***6,102.92***	***71.90***	***10,641.45***			
Gain	1,648.28	129.47	71.46	51.93	20.04	236.55	842.16	249.55	4.74	1,018.02			

Appendix 6. Cross-tabulation matrix or change matrix between t_4 and t_5 (data in km^2).

	2011												
2007	Agriculture	Water	Urban area	Forest	Scrubland	Other vegetation	Pasture	Rain forest	Without vegetation	Secondary vegetation	Total 2007	Loss	Loss rate (%)
Agriculture	**18074.27**	7.39	36.92	0.66	1.51	0.07	199.59	18.70	0.16	138.55	***18477.82***	403.55	0.46
Water	7.80	**2284.98**	0.00	0.00	0.00	7.11	4.75	0.00	8.39	0.96	***2313.98***	29.00	0.37
Urban area	3.07	0.27	**499.34**	0.00	0.00	2.91	3.29	0.00	0.00	0.00	***508.87***	9.53	2.21
Forest	4.69	0.00	0.00	**3533.82**	0.17	0.00	3.51	0.36	0.00	5.89	***3548.43***	14.61	0.02
Scrubland	49.07	0.86	0.00	5.18	**2041.10**	0.00	16.20	7.45	0.00	28.43	***2148.29***	107.19	-0.98
Other vegetation	116.67	28.67	0.45	0.00	0.00	**1538.92**	17.94	9.06	0.98	0.65	***1713.34***	174.42	-2.13
Pasture	380.81	14.14	15.77	1.97	19.84	19.02	**19620.02**	16.94	2.99	57.35	***20148.85***	528.83	-0.07
Rain forest	35.57	0.16	1.84	1.89	1.18	3.73	17.42	**6032.89**	0.39	7.85	***6102.92***	70.03	-0.05
Without vegetation	0.00	5.82	0.00	0.00	0.00	0.00	0.08	0.00	**63.51**	2.48	***71.89***	8.38	1.65
Secondary vegetation	151.25	6.27	1.09	7.24	1.46	0.06	209.27	6.08	0.36	**10258.37**	***10641.45***	383.08	-0.33
Total 2011	***18823.19***	***2348.56***	***555.43***	***3550.75***	***2065.26***	***1571.81***	***20092.07***	***6091.47***	***76.77***	***10500.52***			
Gain	748.93	63.59	56.09	16.93	24.16	32.89	472.05	58.58	13.26	242.16			