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**Working Paper**

## Quantifying NAFTA environmental impacts: Energy and agriculture

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**QUANTIFYING NAFTA ENVIRONMENTAL  
IMPACTS: ENERGY AND AGRICULTURE**

by

**Gloria Soto Montes de Oca**

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## 1. INTRODUCTION

After fifteen years, NAFTA has been subject to many evaluations from different perspectives, including environmental assessments. According to the Commission for Environmental Cooperation (CEC), results of these evaluations show that, at the aggregate level, the environmental impacts of free trade are marginal (CEC 2004). The main sectors analyzed have been energy, agriculture, manufacturing and international transportation. In these sectors, the CEC concludes that results only indicate a concentration of some environmental impacts in specific regions, and the presence of peaks in certain key environmental indicators (CEC 2002). In this paper I argue that environmental impacts might seem marginal because although these were identified, several have been hardly quantified.

For this analysis, the key questions were: what are impacts of the increase in exports and imports in the environment of the members? How could we measure them? And, based on that data, what is the magnitude and significance of those impacts? I develop an *ex post* evaluation; this means to analyze the effects of trade liberalization once they have occurred, consequently showing evidence of these impacts<sup>1</sup>. I used historical data to observe the main trends by production sectors. The data available allowed proving significant impacts of the agriculture and energy sectors on the environment at different geographical scales. I used official historical data set from US and Mexico which was searched with the objective of measuring the environmental impacts of increased trade among the partners. The information that allowed proving these impacts was chosen through an extensive review of available data sources.

I explored two basic hypotheses related to the impact of NAFTA on the environment. Firstly, NAFTA enhanced the energy trade and therefore the production of green house gasses (GHG) responsible for climate change, heightened by a negative environmental effect at a global level. Secondly, greater corn trade produced deforestation and biodiversity loss in Mexico, as poor farmers expanded their agricultural activity into marginal forest and jungle areas to compensate for lost income.

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<sup>1</sup> Ex-post contrast with the ex-ante studies in the way these ones are developed before the free trade agreement occurs (Gallager et al 2002).

## **2. RELATIONSHIP BETWEEN TRADE AND THE ENVIRONMENT**

There is an important amount of literature on the relationship between free trade and the environment (UNEP-IISD, 2000; CEC, 2002; Gallagher et al 2002; CEC 2003). There have been multiple trade agreements around the globe and many of them have assessed the impacts on the environment (Gallagher et al 2002). The challenge of assessing the impacts of trade liberalization is enormous. The complexity is explained by the difficulty of distinguishing the effects on the environment from multiple factors, such as economic growth, trade liberalization policies or, as in this case, a specific trade agreement, among others. A difficulty of proving a clear cause and effect relationship between NAFTA and the environment is that a number of impacts of trade liberalization are beyond NAFTA. In the case of Mexico, for instance, it is difficult to separate the impact of NAFTA from the impacts of trade liberalization policies that started with the GATT in 1986. It is also difficult to isolate NAFTA effects as causes of environmental degradation or improvement because governments in the three countries have strengthened their environmental policy formulation. Furthermore, determining how firms and individuals respond to the economic incentives of NAFTA and how this response affects the environment is not a straightforward issue (CEC, 1999).

To undertake environmental assessments of trade liberalization agreements there have been typically analyzed primary, secondary and even tertiary impacts. Primary effects are explained by the extensive use of natural resources or generation of waste derived from the production process intensification. Secondary effects are indirect, inter-industry consequences of the primary effects, such as expansion of the fertilizers' industry as a response to larger agriculture production. Tertiary effects are the economic equilibrium effects resulting from the primary and secondary effects (Gallagher et al 2002).

Focusing now on the primary effects, we should consider that environment and trade linkages are mainly related to the fact that a greater economic activity is based on a larger consumption of natural resources and a greater waste production, therefore governments' efforts are supposed to be directed at avoiding these negative effects. This means that despite the scale and relevance of trade activity, the effects depend on the extent that appropriate measures are taken to reduce generated negative environmental impacts. However, measures might not have been taken when the harmful effects are related to the transitional process given sectorial or institutional problems that are not foreseen or not quickly overcome. Also, partners might be concerned about specific environmental issues and leave those that are not high in their agendas. In both cases, inaction may incur cost

and these can be enormous (UNEP-IISD 2000). We argue that in the Mexican case transitional effects not foreseen provoked lost of natural resources while in the US case, negligence to attend non-high agenda issues provoked increased emissions.

Another difficulty of assessing the impacts of trade liberalization is given by the availability of adequate data, not only environmental but those related with the productive activity involved. Ex-post studies require long time series data to produce comparable and valid results, which might be only provided by official sources. Besides, in certain cases disaggregated data is necessary to investigate spatial trends; otherwise it is unlikely to isolate the real trade effects in specific locations or to observe how extended the effects are in geographical terms. Statistical information is always better processed in developed countries and restricts possibilities in developing ones. Therefore, within the NAFTA context, the possibilities of finding or discarding a clear cause and effect relationship might be more restricted in Mexico than in the US or Canada.

Here we focused on the energy and agricultural areas. I selected these areas because the data allowed proving the impact of NAFTA on the environment. In fact, this paper does not develop a number of important issues – e.g., biodiversity destruction– because the data is not reported on a basis that permits comparisons.

### 3. ENERGY AND IMPACTS ON CLIMATE CHANGE

Previous environmental assessments undertaken in the US and Canada indicate that none of these countries have to be concerned about the pollution-heaven scenario (Gallager et al 2002). But this might be a partial truth since it has been observed that developed countries are successful in controlling pollution levels that have the characteristic of affecting the local-national environment, but when it comes to controlling CO<sub>2</sub> emissions that are globally damaging but locally harmless, their effectiveness is reduced. This is known as the environmental Kuznet curve that claims that the relationship between per capita income and emissions has an inverted U-shape for most contaminants, except CO<sub>2</sub> emissions (Grossman and Krueger 1991)<sup>2</sup>.

Within this framework, we might analyze what Roff et al. (2003) shows regarding intra-bloc energy trade, which grew with NAFTA and has been characterized by a flow of energy resources from Canada and Mexico to the US. Thus, the hypothesis is that NAFTA increased the potential of consumption of fossil fuels and therefore the production of green house gasses (GHG), responsible for climate change, increased too. Given that the United States has not ratified the Kyoto Protocol which imposes the obligation of reducing GHG, the national government has not taken specific actions to reduce this global pollutants<sup>3</sup>. Therefore, while other countries of the Annex 1 have committed to structural reforms that aim at reducing their impact on climate change, the US has remained reluctant to participate.

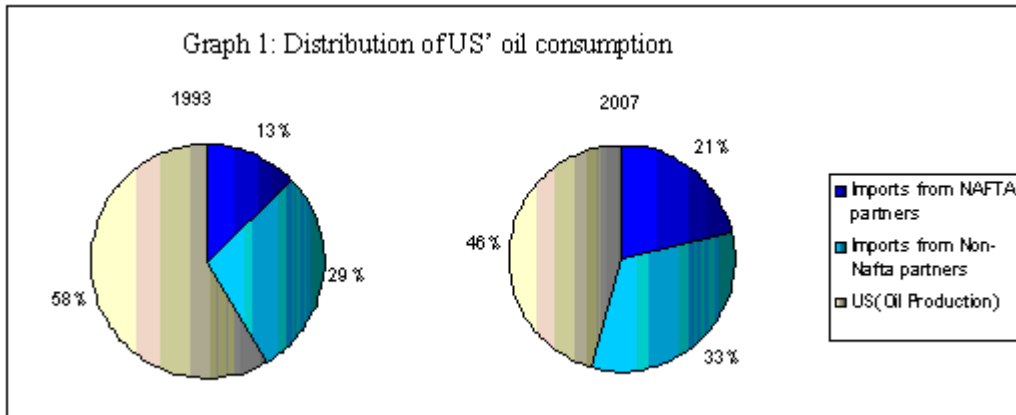
To determine whether energy trade has impacted GHG generation, first of all I analyzed historical data of petroleum and natural gas imports from US NAFTA partners, since 1960 (EIA 2006). The data analyzed comes from the Energy Information Administration, which provides the Official Energy Statistics for the US government.

First of all, we should say that the US is a great importer of petroleum. As Graph 1 shows, US' oil consumption has modified significantly its distribution from 1993 to 2007. National production decreased its share from 58% to 46% during this period, being substituted by imports mostly from its NAFTA partners, which increased its share from 13% in 1993 to 21% in 2007, and also imports from non-NAFTA partners which increased moderately, from 29% in 1993 to 33% in 2007.

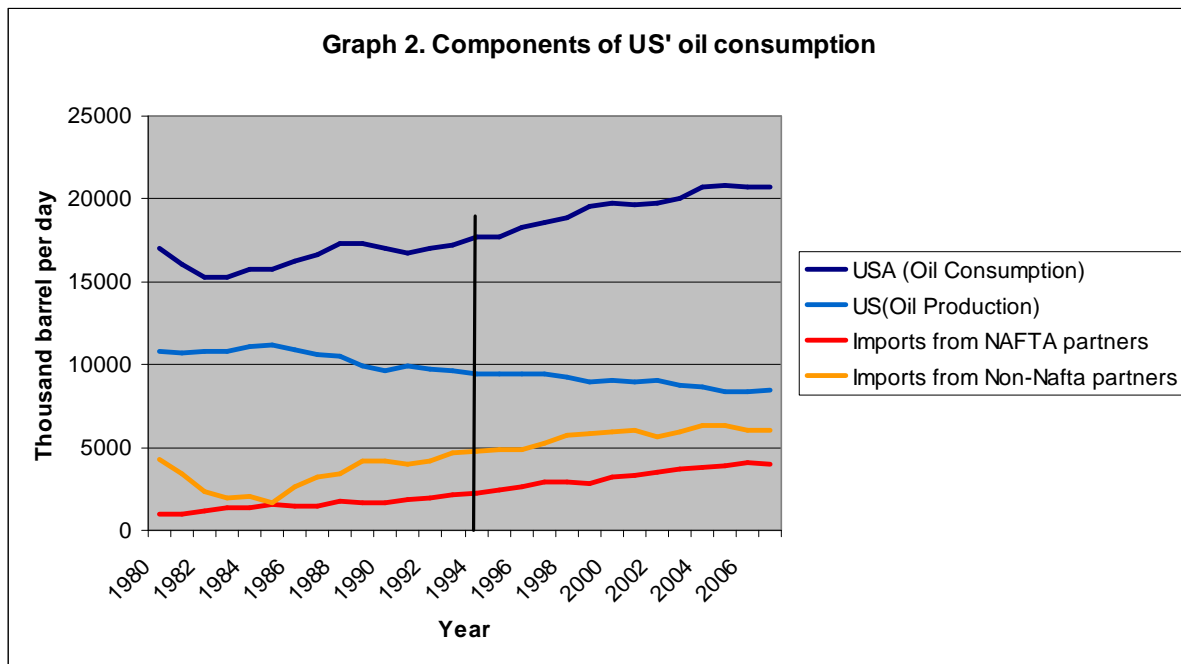
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<sup>2</sup> This behavior is explained by the free rider problem that emerges from the use of a public good, in this case the atmosphere.

<sup>3</sup> In contrast to the national position, several local governments have taken actions to reduce GHG emissions.

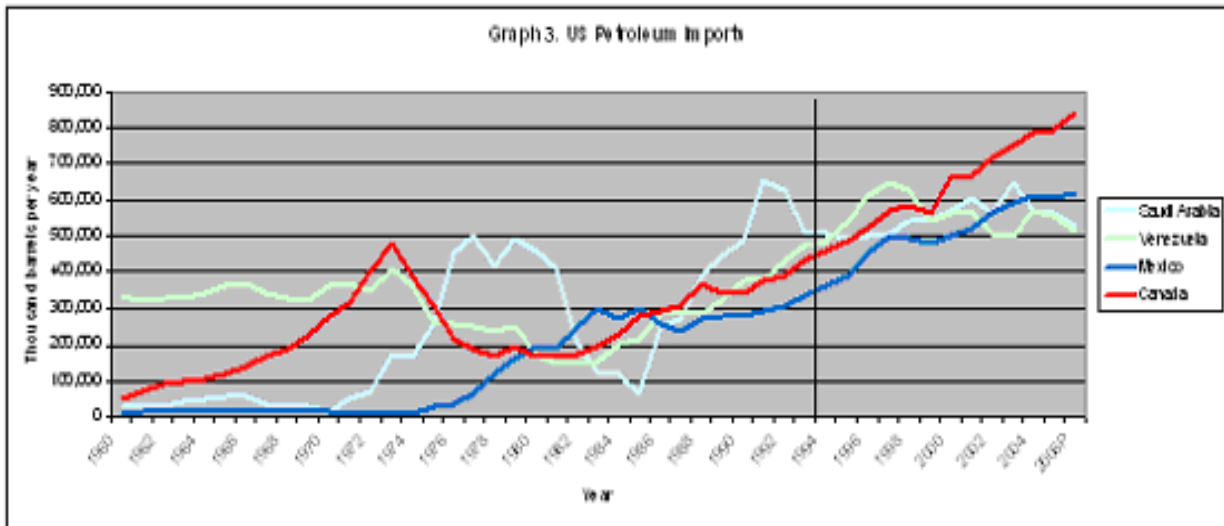


Apart from changes in the distribution, US's consumption levels increased significantly during this period, from 17,237 barrels in 1993 to 20,680 barrels in 2007, this represents a 20% increase (see Graph 2).



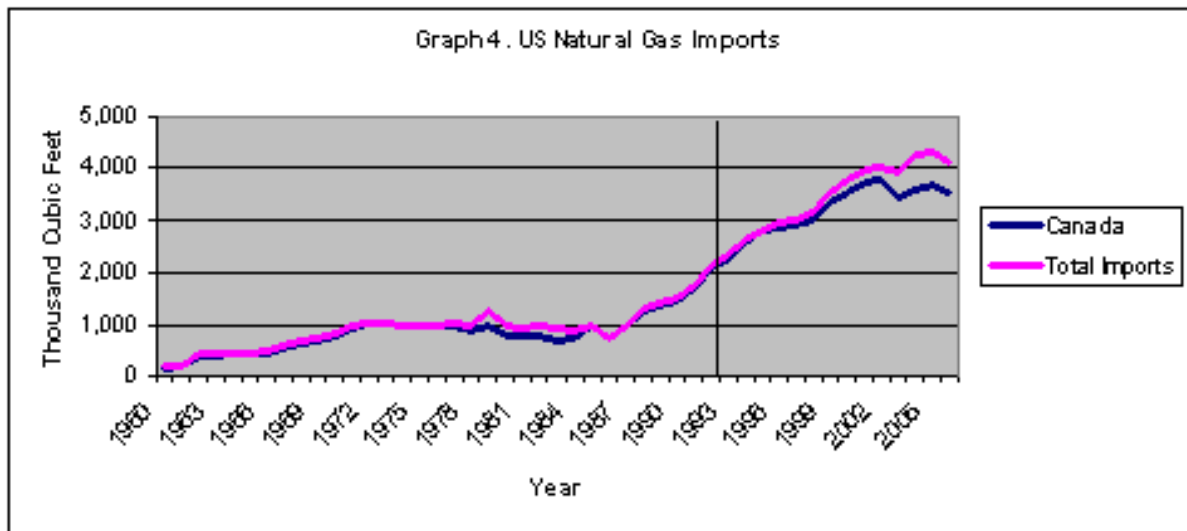
Canada, Mexico, Venezuela and Saudi Arabia are US' largest suppliers, but in Graph 3 can be observed that although petroleum imports from Canada and Mexico were increasing constantly since the eighties, there was a notable increase from 1994: Canada enlarged the number of annual barrels exported to US from 464 million in 1994 to 840 million barrels in 2006 and Mexico from 359 million barrels in 1994 to 620 million barrels in 2006. This represents an export increase of 81 % from Canada and 73% from Mexico during this period. Canada and Mexico exported 19.3% of the US's total oil supplies (EIA, 2006).





Source: Energy Information Administration / Annual Energy Review, EIA (2006).

In terms of natural gas, Canada is the most important US supplier, accounting for 85.7% of its total imports in 2006 and representing 16.4% of the US's natural gas consumption. As Graph 4 shows, US natural gas imports from Canada grew faster since the mid eighties and dramatically after NAFTA, from 2,566 trillion cubic feet in 1994 to 3,555 in 2006, which represents an increase of 72% (EIA, 2006).

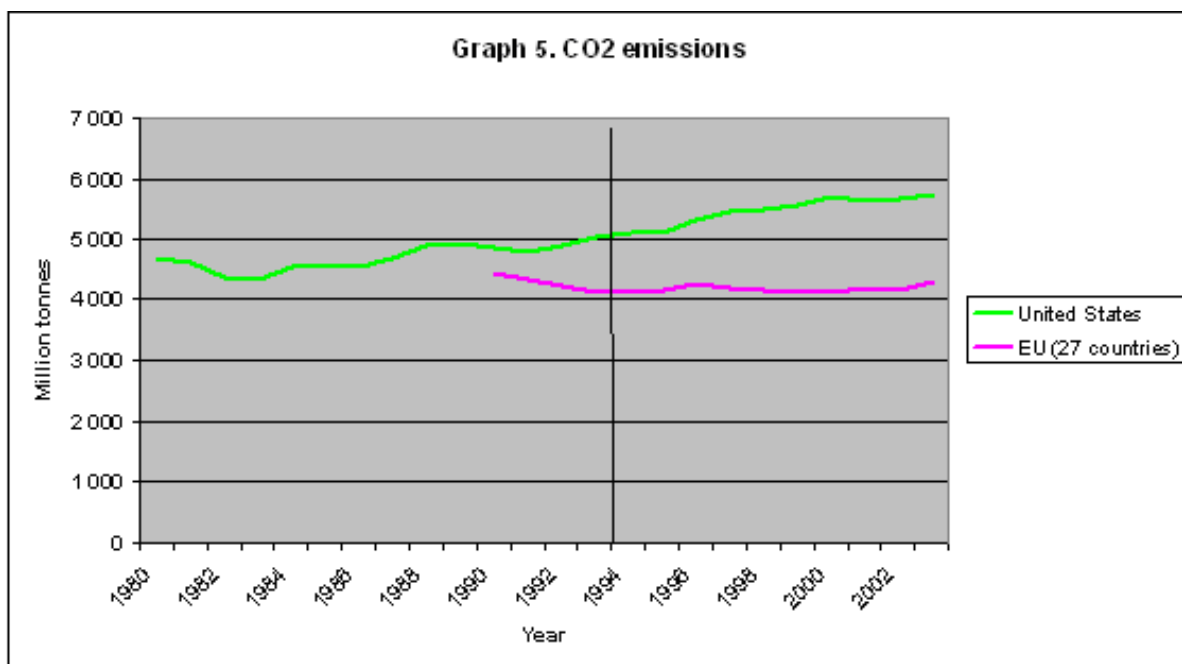


Source: Energy Information Administration / Annual Energy Review, EIA (2006).

The question now is the magnitude of the impacts that this increased trade of petroleum and natural gas had on the generation of GHG emissions. The US has been by far the highest world consumer of fossil fuels and thus the largest emitter of CO<sub>2</sub>. In 2003 the total global emissions of carbon dioxide was 25'168,342 metric tons, with the US generating 23% of

world emissions (equivalent to 19.8 tons per person)--the highest of any country (OECD, 2006).

As mentioned above, an increase in levels of US energy consumption was possible due to the petroleum and natural gas supply obtained significantly from its NAFTA partners. The variation of emissions associated to NAFTA might be observed at first sight in Graph 5 that shows the increasing trajectory of US' CO<sub>2</sub> emissions from energy. It is clear that since 1994, emissions increased relatively more rapidly than in previous years; growing from 5,111 million tonnes in 1994 to 5,729 million tonnes in 2003, which represents a 12% increase for this period, lower than the increase registered from 1980 to 1993 that was of 7.9%. Furthermore, to place this figures in context, we might observe that this grow was faster than that of other developed countries; thus to compare US emissions with the European Union's ones (27 countries), the increase of the European trade block was only 4% in the same period (OECD 2006).

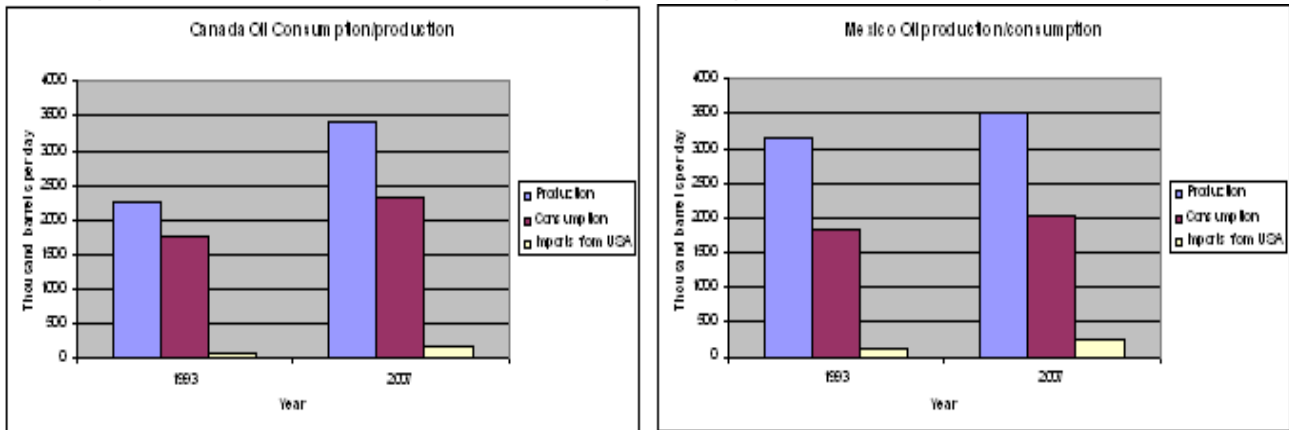


Source: OECD (2006) and EEA (2007).

These data demonstrate the hypothesis that energy trade flow derived from NAFTA encouraged generation of US' GHG emissions. In the US case, the energy trade with its NAFTA partners had a negative environmental impact at a global scale. The US increased its pollution capacity based on free trade and this impact was not restricted since the climate change issue has not been high in the country's agenda. Although, Canada occupies the seventh position as CO<sub>2</sub> polluter, producing 2.6% (14.4 metric tons per person of CO<sub>2</sub>) and Mexico is the eleventh polluter (3.9 metric tons per person of CO<sub>2</sub>); none of these two

countries developed their emission capacity derived from energy trade, given that their increase comes basically from national sources (see Graph 6).

Graph 6: Canada and Mexico's oil consumption and production



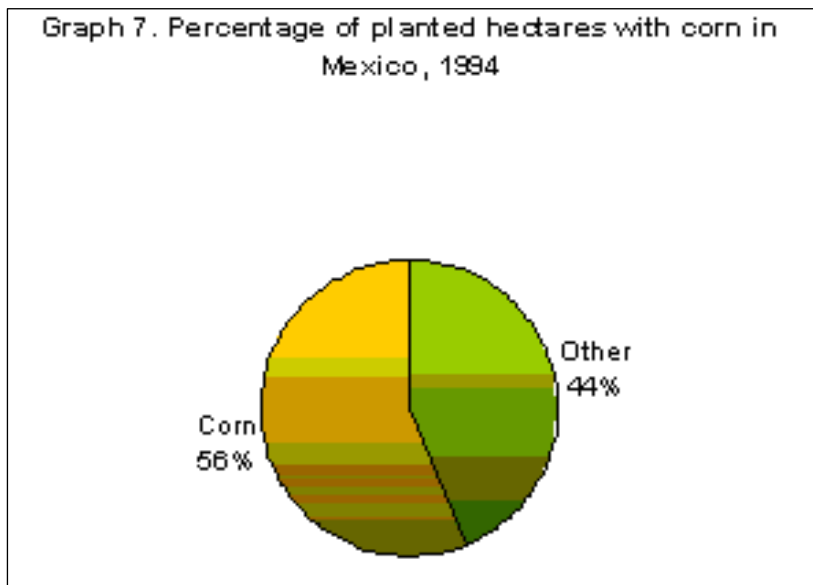
Despite international recommendations, removal of subsidies in the fossil fuel sector or the adoption of specific instruments to combat climate change are absent from the trilateral policy discussions. Although Canada and Mexico have ratified the Kyoto Protocol, the United States has remained reluctant to participate. Therefore, climate change is not considered in the agenda within the CEC context.

#### 4. AGRICULTURE AND IMPACTS ON NATURAL RESOURCES

The environmental impact of agricultural trade liberalization within NAFTA is a well studied area. Most studies have focused on large, intensive operations derived from greater agricultural activities within NAFTA (CEC, 1999; CEC, 2003; Vaughhan, 2004; Nadal and Wise 2005). However, my hypothesis is that deforestation and biodiversity loss were intensified in Mexico as poor farmers expanded their agricultural activity on forest, jungle and other marginal land to compensate for lost income derived from corn trade liberalization<sup>4</sup>. I focused on finding the relationship between corn trade liberalization and loss of forests and jungles. The importance of this impact is heightened by the fact that Mexico's species diversity is ranked as one of the richest "mega-diversity" areas in the world.

We must first consider that agriculture is a land intensive activity that determines the quantity and quality of habitat available for wildlife. It is considered one of the most devastating sources of forest and biodiversity depletion (OECD 1999). Data on land use changes can provide basic information on environmental conditions, because a growing share of agricultural land can be interpreted as a negative sign of forest lost while diversity of species and habitats may be diminishing.

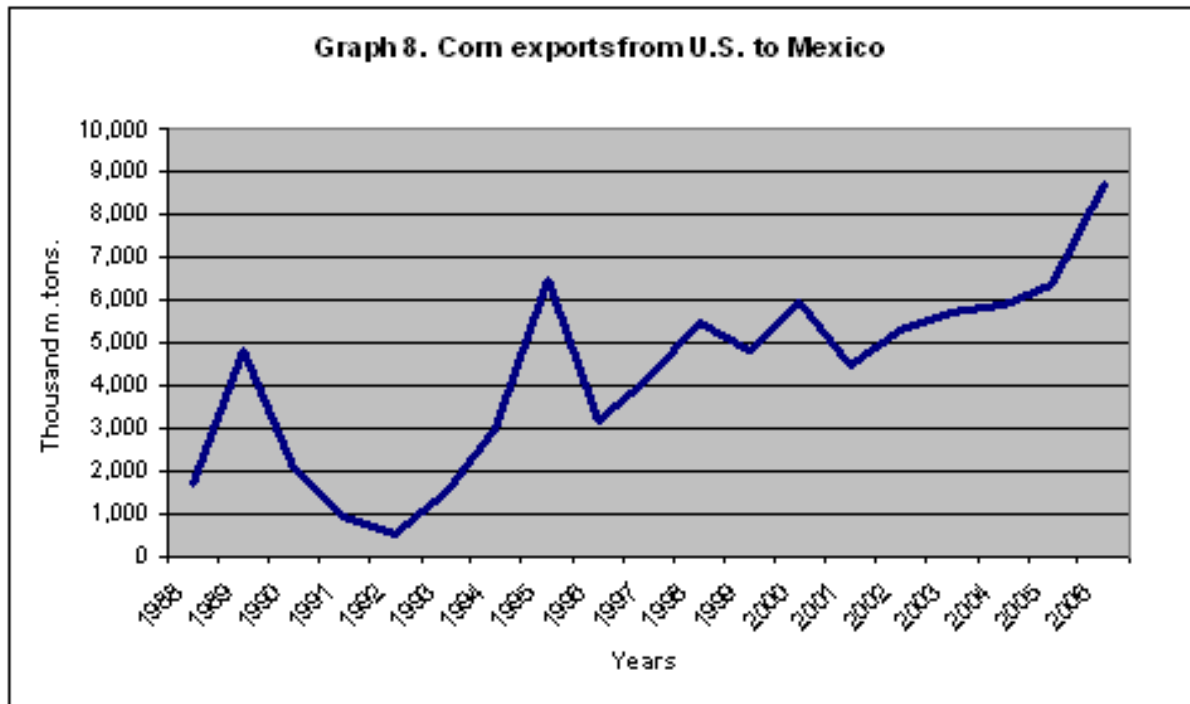
The focus was corn production because this sector occupied 56% of the total land used for agriculture purposes in Mexico (see Graph 7), and practically 3 million people worked in this sector, representing more than 40% of the agriculture working force (SIAP 2008).



Source: Produced with data of SIAP (2008).

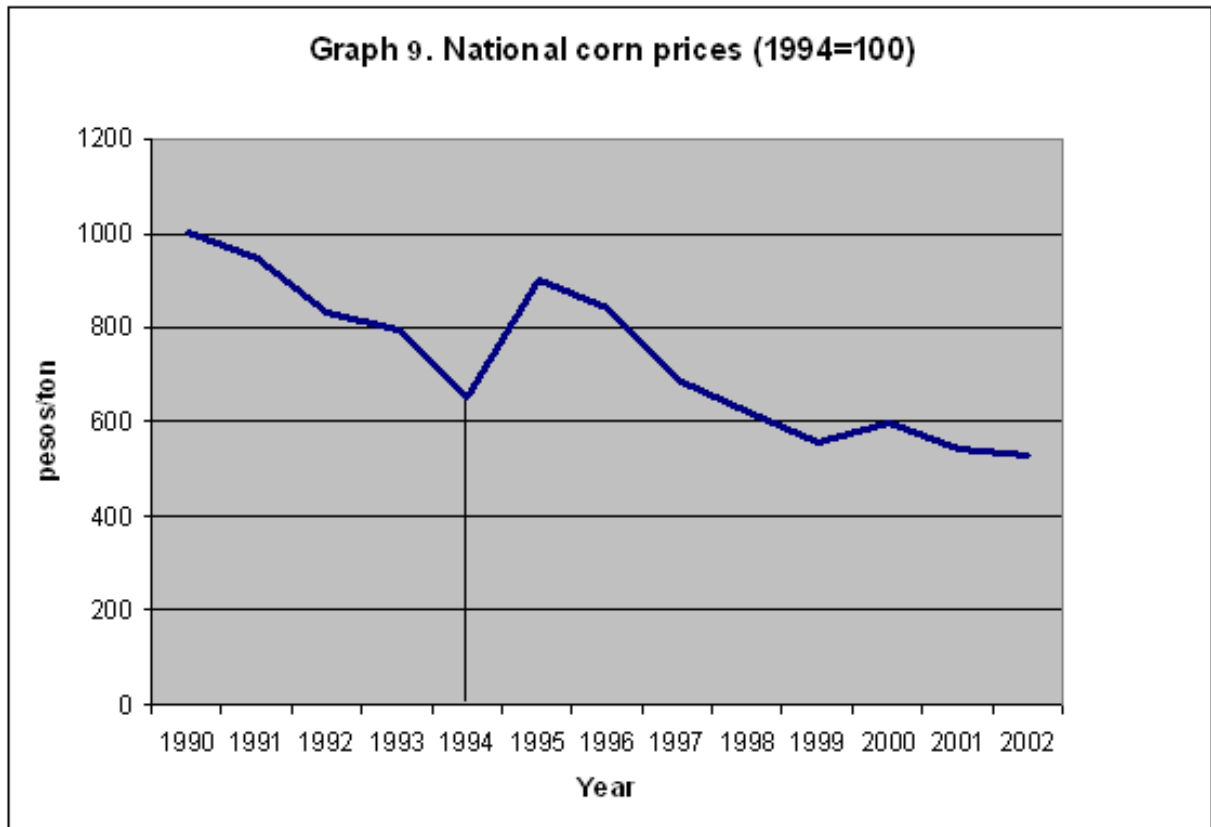
<sup>4</sup> This hypothesis is suggested by the CEC (Kennedy, 2006)

As Graph 8 reveals, liberalization of the corn sector under NAFTA catalyzed a dramatic increase in corn imports into Mexico from the United States. Corn imports grew from about 1,479 million tons in 1993 up to 8,767 million tons in 2006. Mexico became the second US corn importer after Japan, accounting for 11% of US exports in 2002.



Source: USDA, 2008.

These corn imports significantly affected product prices in Mexico. Graph 9 shows the remarkable decrease in corn prices since 1990. Prior to NAFTA, corn prices had experienced an important reduction directly linked to Mexico's entrance to GATT. This price reduction was accelerated by US imports, resulting in a reduction of local prices from about 1002 pesos per ton in 1990 to 530 pesos per ton in 2002, which represents a 47% decrease or, considering just the after NAFTA period, from 656 pesos per ton to 530 pesos, a decrease of 19%. Given this scenario, the government implemented PROCAMPO in 1994, a scheme designed to compensate farmers for the negative price effects of NAFTA. Despite that corn prices saw reductions before NAFTA, as we will explain later, the environmental impact was registered right at the moment NAFTA started and imports of US corn grew.



Source: Vega y Ramírez 2004.

Considering that the corn sector, as many others, was highly protected, most of the producers were unable to compete with lower prices. Diverse studies argue that this market conditions polarized the farm sector, creating at one end million small scale producers unable to compete, and on the other, a much smaller number of larger farm operators. Evidently, PROCAMPO subsidy did not change this trend and increased competition lead to redefine the situation of the not competitive farmers. An economic logic indicates that as a result of lower corn prices, producers would be more likely to change their activities in search for other higher, profitable options. A CEC (1999) analysis distinguished five likely changes in productive strategies in the agricultural sector derived from NAFTA: first, modernization of corn production; second, crop substitution (horticulture and other grains); third, land use changes for livestock; fourth, reallocation of household resources and changes in social organization with a migration effect and, fifth, persistence of corn production.

My analysis mapped the impacts of the price fall on the number of corn hectares planted across the country in order to observe whether there was a land use change during these years. I used annual state data from the Official Agriculture Statistics for the Mexican government (SIAP, 1998) to trace out the fluctuations in corn hectares planted, distinguishing

between irrigated and non-irrigated lands. This distinction was given because non-irrigated lands are mainly owned by poor subsistence farmers, hence it allows observing response differences between groups.

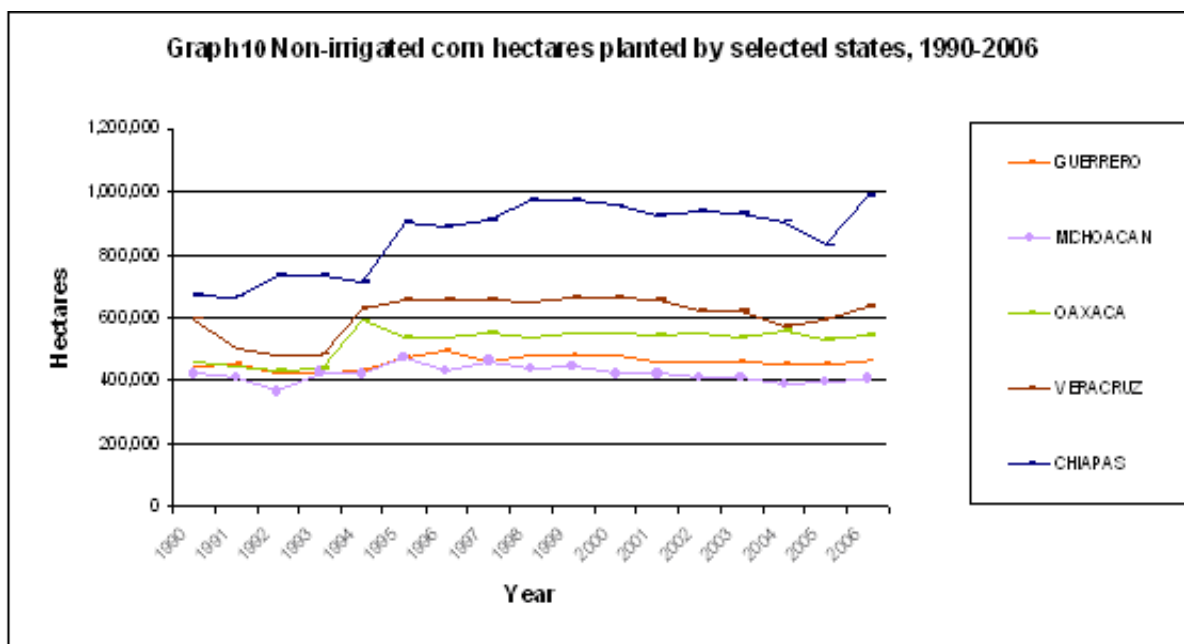
Results show that, as expected, irrigated areas planted with corn shrunk 29% from 1994 to 2006 (SIAP 2008). Most states registered reduction in irrigated corn hectares planted and few presented minor increases<sup>5</sup>. Nevertheless, this trend is not generalized in the case of non-irrigated lands. The analysis shows two patterns:

- A group of states that registered non-irrigated lands showed a reduction in corn hectares planted between 1990 and 1995. In this first group, states presented the same pattern as irrigated lands; this means a reduction of non-irrigated corn planted areas. The rationality might be that NAFTA influenced longer-term production farmers' decisions; resulting in the reduction or abandonment of corn production. These states were Aguascalientes, Distrito Federal, Durango, Guanajuato, Jalisco, México, Puebla, Sonora and Zacatecas.
- Another group of states showed an opposite trend of significant increase in non-irrigated corn growing areas. In this second group, the corn non-irrigated areas increased 664,000 hectares in 14 states from 1990 to 1995. This second group includes Campeche, Chiapas, Guerrero, Michoacan, Nayarit, Oaxaca, Queretaro, Quintana Roo, San Luis Potosi, Sinaloa, Tabasco, Tamaulipas, Veracruz and Yucatan.

Graph 10 and 11 show how non-irrigated corn areas increased as NAFTA got implemented. Graph 10 reveals trends for those states with the largest non-irrigated corn surfaces in the period 1990-2006.

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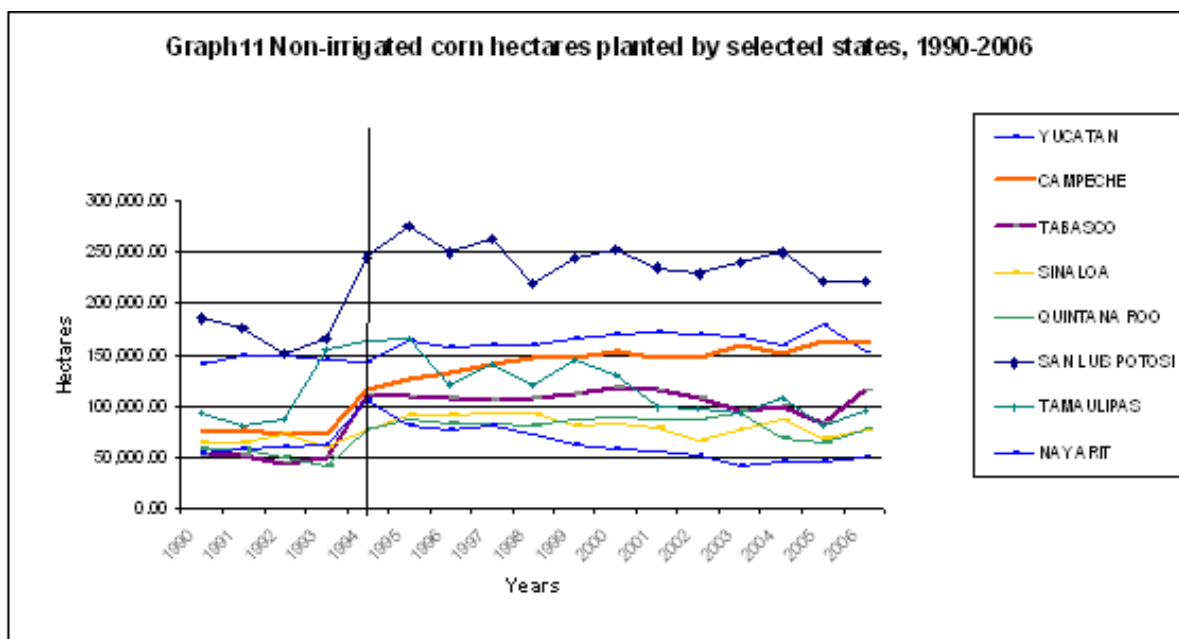
<sup>5</sup> The only exception is Sinaloa that increased about 58,000 hectares the number of irrigated areas planted with corn.



Source: Produced with data of SIAP (2008)

Graph 11 shows the states with corn planted surfaces lower to 200,000 hectares. The number of hectares that were added as non-irrigated land indicates a process of land use change that was given precisely in this period. As we might observe, Chiapas registered the largest increase in its non-irrigated corn areas with 232,916 hectares; which represented a 35% growth for the period. In absolute terms, other states registered important increases such as San Luis Potosi (89,092 hectares), Oaxaca (79,897 ha) or Tamaulipas (74,369 ha). In relative terms, Tabasco doubled its non-irrigated corn land (108%); Campeche presented an increase of 69% and Quintana Roo of 51%.





Source: Produced with data of SIAP (2008)

Table 1 reports the number of hectares that were added as non-irrigated land between 1990 and 1995. The influence of this land use change derived from NAFTA is indicative of deforestation. We might relate this deforestation impact based on the National Forest Inventory that estimates deforestation rates in Mexico for fixed time periods (INE, 2008). Mexico lost a total of 12'031,728 hectares of forests and jungles between 1976 and 2000. Column 4 shows the number of forest and jungle hectares lost at the state level, and column 5 presents the percentage of forest and jungles lost corresponding to NAFTA in the period. In disaggregated terms, Chiapas lost 968,467 hectares of forest and jungles between 1976 and 2000 and, as mentioned above, 232,916 hectares were converted to non-irrigated corn lands; this implies that NAFTA's likely effect contributed with 24% of the forests and jungles lost of this period. Other states that registered an important effect were San Luis Potosi, where direct conversion of forest and jungle areas to non-irrigated corn lands accounted to 89,092 hectares, which represented 38% of the forests and jungles lost for the whole period. The relative importance of deforestation due to greater small scale corn agriculture was also significant in Tabasco (31.5%), Oaxaca (17.3%) and Campeche (10.4%).

**Table 1: Patterns in land use change derived from NAFTA**

State	Hectares increase non-irrigated lands 1990-1995 (1)	Percentage increase non-irrigated lands 1990-1995 (2)	Lost of forest and jungles hectares 1976-2000 (4)	Percentage lost of forest and jungles corresponding to NAFTA in the period 1976-2000 (5)
	Ha	%	(Ha)	%
CAMPECHE	51,802	68.9	497,185	10.4
CHIAPAS	232,916	34.7	968,437	24.1
GUERRERO	30,146	6.8	761,760	4.0
MICHOACAN	48,771	11.5	503,742	9.7
NAYARIT	26,214	48.6	266,757	9.8
OAXACA	79,897	17.4	463,038	17.3
QUERETARO	3,916	4.9	76,867	5.1
QUINTANA ROO	29,210	50.7	634,103	4.6
SAN LUIS POTOSI	89,092	47.9	239,086	37.3
SINALOA	27,493	43.1	313,933	8.8
TABASCO	56,450	107.6	179,169	31.5
TAMAULIPAS	74,369	80.9	559,298	13.3
VERACRUZ	60,894	10.2	709,925	8.6
YUCATAN	23,558	16.7	850,838	2.8
<b>TOTAL</b>	<b>664,003</b>		<b>12,031,728</b>	

Source: Produced with data of SIAP (2008) and INE (2008)

Taken as a whole, these results indicate that poorer farmers in several states decided to deforest their lands in order to increase corn planted areas to compensate their income loss. This finding is explained by the linkage between poverty and environment. Guevara (2003) describes two characteristics that might explain this result. First, poor people are more concerned with present than future horizons, thus when they make a decision on productive activities, they would more likely choose those with higher short term profits, in this case

corn production. Second, in the rural sector this phenomenon is emphasized when there is absence of alternative productive activities, as in the case of Mexico.

The environmental implication of land use change is not solely deforestation, but as Turner *et al* explain, there are other ways in which land use change affects biological diversity:

- Alteration of the relative abundance of natural habitats results in the establishment of new land-cover types.
- Fragmentation of a once-connected or continuous habitat.
- Extending the boundaries and duration of natural fires, or increasing flooding.

In this case, a worrying situation is that the increase in land use change was highest among the states classified as those with the greatest biodiversity. Table 2 reports the number of registered floral (column 3) and animal species (column 4). First, it is worth noting that at the national level, the states with more plant and animal biodiversity registered are Oaxaca, Chiapas and Veracruz, which are among the ones that registered important land use changes. An indicator for assessing the impact of land use change is the number of endangered species. Column 5 shows the number of endangered species. Again Chiapas, Oaxaca and Veracruz are the most affected. Despite the fact that we might observe certain relationships between land use change and number of endangered species; it remains difficult to estimate accurately the extent to which this phenomenon affected biological diversity. Nevertheless, as suggested by literature, given the land use change registered, there is an indication that NAFTA might have contributed to lost species, habitat fragmentation or destruction of plants and animals in the states with the greatest biodiversity.

**Table 2: Biodiversity indicators and land use change derived from NAFTA**

State	Hectares increase non-irrigated lands 1990-1995 (1)	% increase non-irrigated lands 1990-1995 (2)	No. of floral species (3)	No. of animal species (4)	No. of endangered species (5)
CAMPECHE	51,802	68.9	222	448	13
CHIAPAS	232,916	34.7	2,015	1,095	98
GUERRERO	30,146	6.8	1,014	771	60
MICHOACAN	48,771	11.5	985	780	39
NAYARIT	26,214	48.6	805	608	29
OAXACA	79,897	17.4	2,141	1,204	115
QUERETARO	3,916	4.9	354	298	13
QUINTANA ROO	29,210	50.7	279	513	13
SAN LUIS POTOSI	89,092	47.9	913	719	40
SINALOA	27,493	43.1	535	670	10
TABASCO	56,450	107.6	355	541	20
TAMAULIPAS	74,369	80.9	833	672	38
VERACRUZ	60,894	10.2	1,863	1,098	116
YUCATAN	23,558	16.7	304	513	20
<b>TOTAL</b>	<b>664,003</b>				

Source: See table 1 and CONABIO (1998)

## 5. DISCUSSION

Based on the analysis of energy and agriculture within the NAFTA framework, I observed that trade impacts are fundamentally related to the type of environmental challenges that face developed and developing countries. Results indicate that the US's impact on climate change was powered by NAFTA energy trade. The capacity of producing an impact of this magnitude is a characteristic of development and industrialization, furthermore when there is a lack of measures to control global emissions. Other trade impacts are related to underdevelopment and poverty, given that poor people affected by trade might have taken short term decisions that lead to forest resource depletion and therefore to effects on biological diversity. Despite these significant differences between Mexico and the US's performance, the resulting environmental negative effects had regional and global magnitude.

Regarding the potential of an ex post analysis, by collecting a broad range of historical data that make time comparisons possible, this analysis could quantify the magnitude of NAFTA's impact in key issues. This suggests that a more quantitative approach might reduce the uncertainty about trade impacts in order to empirically evaluate trade results. The existence of official data provides a unique opportunity to observe specific impacts. Nevertheless, the difficulties experienced in the course of this analysis are mainly related to data gaps which reduce the possibility of finding specific trade impacts in other areas, such as biodiversity.

The results show that although NAFTA was at the forefront in terms of innovative schemes to prevent negative environmental effects, partners were unable to prevent significant environment degradation of specific sectors. Future trade agreements might consider agriculture and energy environmental impacts and try to design precautionary policy responses. In this case, despite the fact that the US had a greater potential for reducing negative environmental impacts of trade liberalization, it did not guarantee it. The need for improved diagnosis regarding possible effects of trade agreements might provide inputs for better environmental national policymaking to reduce environmental costs at the regional but also global level. Consequently, an important policy conclusion is that interventions must pay close attention to the relationship between poverty and environment in developing countries and CO2 emissions in every party.

The results from this article raise several interesting questions for future research in the area of NAFTA's impact on the environment. One clear direction for future research is to analyze whether other likely changes in productive strategies in the agriculture sector derived from

NAFTA affected the environment, among them modernization of corn production; crop substitution; land use changes for livestock and changes in social organization with a migration effect. Also the issue of trade agreements among parties with heterogeneous development conditions requires further study. Results from this article suggest that evaluations of trade agreements should be sensitive to heterogeneous environmental impacts due to the multiple aspects of the relationship between trade and development levels.

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