The Impact of Foreign Direct Investment on Mexico's Agricultural Sector and Forests

An Honors Thesis for the Department of Economics

By: Timothy Biller

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I. Introduction

As the world economy has opened up and borders have become less of a barrier to trade, there has been a growing trend of spreading investments into different nations around the world. This diffusion of investments is often directed toward developing nations where inputs such as labor and raw materials tend to be less expensive than they are in the developed world. This movement to developing nations has sparked a considerable amount of debate on the impacts that it has on labor, the environment, and a number of other areas in the receiving nations.

The particular movement of investment that is the focus of this study is foreign direct investment (FDI). FDI is any investment by a firm from one country in the actual productive capacity of another country. This can take the form of a physical investment such as a foreign firm building a factory in a country or it can be when a firm invests money in a foreign firm and is granted part ownership or some other amount of control in the foreign firm. By definition the foreign firm owns 10% or more of the shares in the firm or holds 10% or more of the voting power.

The purpose of this study is to expand upon the already existing debate on the environmental impact of FDI on developing nations and to highlight some areas of the debate that have not received as much attention as they probably deserve. The particular areas of interest in this study are FDI's impact on agricultural labor and, through this, its effect on forests. Specifically, it asks what impact foreign direct investment has on the economic decisions of the inhabitants of the host region and how this subsequently impacts their employment decisions and their use of forests. The purpose of asking this question is to see whether the amount of FDI in an area affects an individual's choice of employment and if this shifts them away from occupations in agriculture and into other jobs such as manufacturing or service industries that are stimulated by FDI. For the purpose of this study, agriculture is assumed to have a negative impact on forests as trees are cleared to expand agricultural land and therefore when fewer people are involved in agriculture, pressure on local forest lands will be alleviated. This easing of pressure on the forests and decline in deforestation rates will be invaluable in preserving a stable environment and the environmental benefits that can be derived from forest lands. Forests help to keep land stable and prevent significant erosion and degradation of the nutrients in soil. Without the trees to keep the soil in place and to cycle the nutrients in the soil, deforested land can quickly become unusable. They also provide valuable habitat for wildlife, providing food and shelter for a variety of animals. In addition forests also provide benefits to humans for things such as recreation and scientific research. The difficult part of dealing with deforestation is that there is no real market for these benefits and they are therefore often ignored in normal economic decision making processes. (Barbier and Burgess 1997) Since this study will look at more traditional economic markets (such as the agricultural labor market) and then expand upon this to show what affect there is on agricultural labor and that it may have more far reaching impacts and possibly provide a benefit to the environment that may otherwise not be fulfilled.

Mexico will be the focus of this study of FDI's impact on agriculture and deforestation. This is two reasons, the first of which is due to Mexico's proximity to a large developed nation (the US) and its inclusion in the North American Free Trade Area (NAFTA). As a result of this, Mexico has seen a large amount of FDI focused on industries such as manufacturing with little going into the agricultural sector. Second, Mexico contains a large stock of forest land that has been put under a lot of pressure through deforestation. Estimates put the rate of deforestation in the range of 400,000 to 1,500,000 hectares per year, with the majority of this being in the tropical forests of southern Mexico where a large amount of agriculture is also located. (Barbier and Burgess 1998) These two reasons make Mexico a country for which there is a large potential exists to document a relationship between FDI and deforestation.

In general FDI can be seen as having two distinct levels of impact on the environment in the host countries. The primary impact comes from first-order, or direct effects. These effects arise as a result of the activities of the investing company such as pollution that results from the manufacturing process or other activities that the company may be directly involved with. Second-order effects, on the other hand, are the impacts that result because of the impact of the investment on the area into which it occurs other than the direct effects that pollution has on things such as health and environmental quality. For example, this paper is concerned with a second-order effect where the investment stimulates the manufacturing labor market which in turn has an affect on agricultural lands and forests.

The current debate on the environmental impacts of FDI typically approaches the topic with a negative view of the motives of foreign entities by attempting to identify the associated negative impacts that these companies have on the environment in the receiving country. Most studies focus on the 'pollution haven hypothesis' and similar questions that look at the direct impact that this new capital has on the environment in terms of pollution levels generated. (Xing and Kolstad 2002; Smarzynka and Wei 2001; Letchumanan and Kodama 2000; Eskeland and Harrison 2003) They look at the motives of the foreign firm and try to identify if there is a pattern of moving to countries with little environmental controls specifically in order to cut costs for environmental protection measures. Most of these studies have not found sufficient evidence to support the theory, leading many researchers to believe that it does not actually exist.

What has not been well analyzed in most studies is the second-order, or indirect, impacts on the environment specifically that may arise from the investments made in a country. This is where the present study contributes to the FDI debate. By correlating amounts of foreign direct investment with employment in agriculture and then establishing a relationship between this change in labor and a change in croplands, an indirect relationship can be established between the increase in capital moving into the country and a movement away from practices that harm the country's forests.

It is not the intent of this study to give a conclusive answer to the question "is FDI ultimately good for the environment?" It also does not attempt to say that FDI will end deforestation or any similarly conclusive statement, but rather it documents that there are indirect effects of FDI that can actually reduce the level of deforestation, a problem that has often proven hard to control by way of policy. The intent of this study is to shed new light on the debate by opening up new ideas and provide evidence to support these ideas that can be considered when evaluating the merits of FDI.

One of the most difficult parts of conducting a study of deforestation is obtaining reliable data on forests. Barbier and Burgess (2001) discuss the various problems with the most common data sets for forest data. These problems include the fact that most major sources for deforestation data use population growth projections to estimate deforestation in order to deal with an inadequate forest data base. Many other sources are also insufficiently disaggregated to use in a detailed analysis. To avoid these problems, many researchers have employed other methods of accounting for forest land such as using agricultural land expansion as a proxy (Barbier and Burgess 1998) or using satellite images and geographic information systems (GIS) technology to estimate forest cover over time (Chomitz and Gray 1996).

Both methods have been employed and each have their relative merits, but so far have been used to analyze deforestation from different perspectives. Studies using agricultural land expansion as a proxy have typically identified input and output prices for agriculture and other economic data as the focus of their model. However studies utilizing GIS techniques have typically used more spatially related variables such as roads and distance to market as the major focus of their model. This study will combine the two ideas and use primarily GIS based data to account for the agricultural lands. This will be used in conjunction with economic data in order to estimate the relationship between employment generated by FDI and the decrease in pressure on forest lands from agriculture. This has the benefit of potentially being more accurate in terms of accounting for the croplands than traditional sources for this data that are not widely available and often hard to find.

This study finds that foreign direct investment does appear to have a negative impact on employment in agriculture. The data indicates that labor has moved out of the agricultural sector, presumably into other sectors which have had a positive growth at the same time as agriculture's negative growth in employment. It shows that a 1% increase in FDI will lead to about a .13% decrease in agricultural employment. This contraction of the agricultural sector has resulted in a reduction in the amount of croplands being utilized which the data shows is about 2.6 hectares per agricultural employee. This reduction in croplands in turn decreases the amount of forest land being converted into croplands which is documented through the use of the GIS data.

This study has made a number of contributions to the various areas of literature that will be reviewed below on FDI and deforestation. It is relatively unique in empirically estimating the impact of FDI on deforestation. It also uses a combination of economic data and GIS satellite data to show this relationship in an attempt to foster new ways of looking at the economic causes of deforestation and how best to account for these.

This paper proceeds as follows: Section 2 reviews the relevant literature on the environmental consequences of FDI as well as the relevant literature on deforestation. This section is intended to provide an overview of where the literature has typically focused on these two topics in order to give a better idea of this study's contribution to them. Section 3 develops the theory that lies behind the analysis used. Section 4 covers the data sources and the methods that were used to collect the data. Section 5 discusses the empirical methods employed and the results. Section 6 concludes and offers ways in which this topic could be explored and expanded in future research.

II. Literature Review

The literatures on foreign direct investment and deforestation do not often overlap and there have been few studies that actually try to draw a relationship between the two. However, many researchers have investigated a variety of subjects that, when examined together, help to form a basis for the theory used in this paper to explore the impact of FDI on deforestation. To see this connection it is also necessary to review what the debates on these two subjects have already examined in order to get an idea about where the present study attempts to add to them.

Copeland and Taylor (2004) present a relatively comprehensive survey of the debate over the impacts of trade on the environment. However, their survey centers on the general discussion about pollution generation or the first-order effects of trade and does not explore beyond these to the second-order effects that trade may have on the environment. They point out that they do omit an important discussion of renewable resources and non-renewable resource use and sustainability, but admit that this would take them too far away from their central idea. This seems to be the general attitude in the literature, with the majority focusing on issues of pollution connected with growth and trade and not expanding this debate to any second-order effects.

The most common theory in the literature on trade and the environment is the so-called pollution-haven hypothesis. The pollution-haven hypothesis is essentially the idea that multinational industries will tend to relocate to countries with weak environmental protections. It is theorized that companies in industries with high pollution control costs will move to countries with these lax standards and pollute more than they would if they were located in areas with more stringent pollution control regulations. Although there have been some mixed results as to the validity of this theory, most have not found sufficient evidence to support it. A majority of papers on the pollution haven hypothesis point out that there are shortcomings in the data that many studies of this hypothesis use, pointing out that it is difficult to get a good measure of laxness in environmental regulations and other important variables. Some studies, such as that by Xing and Kolstad (2002), use different measures for some of these variables in an attempt to fix the common shortcoming in the data. They do report a positive association between FDI and where heavily polluting industries locate, however, as Smarzynka and Wei (2001) point out; there are very few observations in their country and industry level analyses which lead to questions about the robustness of their results. Smarzynka and Wei also find a small association when they attempt to fill in the gaps in the data, although they admit that these results do not hold up to various tests of robustness. More recent studies also show that the pollution-haven hypothesis does not hold up in almost all empirical studies of the data. (Letchumanan and Kodama 2000 and Eskeland and Harrison 2003) Overall this theory has found little positive support, but has still been the main focus of the literature on the environmental impact of FDI and trade.

Another major theory that relates to trade and the environment is the Environmental Kuznets Curve. This theory says that there is a relationship between per capita income and environmental quality that forms an inverted U similar to the famous Kuznets curve for income inequality in developing economies. This relationship says that initially as per capita income rises in a poor country there is a decrease in environmental quality, but at some critical point as per capita income grows environmental quality begins to improve. This idea originated from the seminal work of Grossman and Krueger (1993) through their work examining possible environmental consequences of NAFTA for Mexico, particularly with levels of air pollution. It is theorized that as trade is increased in a country per capita income will increase proportionally and environmental quality will follow the inverted U pattern of the Kuznets Curve.

There are also a number of papers that deal with deforestation from an economic point of view. Almost all of these papers agree on the fact that agriculture has a direct relationship with deforestation and many of these agree that expansion of agricultural lands can be a good indicator of deforestation in an area when direct information is not available. These papers however only tend to look at the most immediate causes of agricultural expansion and deforestation such as prices of inputs and outputs, accessibility, and other things that directly influence the profitability of engaging in agriculture or other forest clearing activities.

Barbier and Burgess (1998) review some of the various ways in which economists have approached empirical analyses of deforestation. They mainly focus on cross-county analyses, but stress that there is a need for more country level and local case studies. Their paper presents four basic models that have been used to analyze deforestation: environmental Kuznets curve analysis, competing land use models, forest land conversion models, and institutional models.

The environmental Kuznets curve (as described above) provides some insight on the issues surrounding deforestation except that the results of most studies that look at it are mixed and do not produce any definitive statement about deforestation patterns. Cropper and Griffiths (1994) find that an inverted-U relationship between forest loss and GDP per capita (with other factors such as population density taken into account) does appear to exist for Latin America and Africa, but not for Asia. They also find that the income at which deforestation is zero is much higher than the average per capita income for the regions for which they found this relationship. Koop and Tole (1999) also attempt to determine if there is an inverted-U relationship between deforestation and GDP per capita but show, in a less restrictive model than that employed by

Cropper and Griffiths and others use, that the inverted-U relationship does not appear to be a regular phenomenon in the data between different countries. They attribute this change from the more restrictive models to the wide range of physical and social characteristics that exist between countries which their model took into account. As these studies show, there does not appear to be any definitive evidence of an environmental Kuznets relationship; however the results do show that, in general, as economic conditions improve in a country there is less pressure put on the environment from different sources.

The competing land use model is not widely used as it requires data that is hard to get, especially for cross-country analysis (which is what has mostly been done for models of deforestation because of a lack of detailed deforestation data as mentioned above). The basic concept of the model is that forest loss is a result of competing land uses, especially between maintaining natural forest and agriculture for the country or region as a whole. Essentially the opportunity cost of deforestation and conversion into agricultural land must account for the lost benefits of timber production and other benefits from maintaining the forest land. It is difficult to do this type of analysis because a large number of proxies must be used since there are not good measures of land values and timber rents across countries that can be used to account for the opportunity cost that is essential for the model.

The forest land conversion model is the one that has been drawn upon heavily in the formation of the theory for the present study. It uses the same underlying trade-off between natural forests and agriculture as in the competing land use model, but looks at it as an issue at the household level instead of at the country or region level. This eliminates the competition between forestry and agriculture for the land and looks instead at the demand of individual smallholders for converted land based on a number of factors such as prices of inputs and outputs, wages, and accessibility of the land. (Barbier and Burgess 1998; Lopéz 1997; Chomitz and Gray 1996; Nelson and Hellerstein 1996; Anglesen 1999) These studies tend to be carried out on the country-level or lower and have taken a number of different approaches to using this basic model. Barbier and Burgess (1998) develop a model for the causes of deforestation in Mexico by examining the different returns on land use options, or more specifically maize prices, fertilizer prices, and cattle prices. They also analyze other factors such as population density and road density, but ultimately conclude that maize and fertilizer prices appear to be the main influences on the expansion of planted area and cattle prices and credit disbursement are the main influence on cattle numbers.

The papers by Chomitz and Gray (1996) and Nelson and Hellerstein (1996) were some of the first studies to take a different approach to accounting for deforestation by using satellite images and GIS technology to obtain a new measure of deforestation. Their models take into account spatial characteristics of the surrounding area such as roads, distance to market, as well as soil and land characteristics that impact the returns to agriculture. These papers have done a lot to open up the availability of data and have spawned a completely new avenue for economic evaluations of deforestation.

A number of papers that deal with deforestation also incorporate elements that are central to looking at how foreign direct investment could impact deforestation. Anglesen (1999) compares four different approaches to modeling smallholder agricultural land expansion and deforestation which incorporate varying labor markets available to the farmer (as well as other conditions such as a household's objectives and property rights regimes). The models used also assume that all agricultural expansion takes place into forested land. Anglesen states that this is not quite the case, and therefore, in empirical work, agricultural expansion should not be completely equated with deforestation across the board. However, he says that it has been estimated that it averages 50% of deforestation and therefore can be used in some instances to get an idea of deforestation.[1] The models that assume that there is an outside labor market indicate that the availability of alternative employment has a strong affect on reducing deforestation (agricultural land expansion). This is one of the main conclusions of the paper and leads to recommendations for developing off-farm sectors of economies as a way to take pressure off forests.

Barbier (2000) also mentions off-farm employment as something that is a 'second-order' effect on the decisions of households in their land-use decisions and may have a significant impact; however it is outside the scope of his present model of the 'first-order' effects such as prices of inputs and outputs as well as accessibility. In their paper on how policies impact sustainable agricultural intensification and household's decisions to engage in this process, Reardon and Barrett (2001) deal with the issue of off-farm employment and income directly in their model. They sum up the impact of off-farm income and employment as:

> If off-farm employment pays more than farm labor and/or helps to reduce overall income risk, then farmers will generally not want to adopt labor-using technologies. Similarly, if off-farm work pays more than farm work at the margin, labor freed from agricultural production on existing lands will generally not be shifted to bringing more land under the plough. (Reardon and Barrett 2001, 237)

They also note that as agriculture is intensified (through technology) and productivity increases, there is a rise in demand for non-farm goods and services, increasing the activities of the rural

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[1] It is not stated in the paper if he is referring to a specific region of the world when discussing the applicability of using land expansion to account for deforestation. He is most likely correct if one was to look at deforestation in the world as a whole, however, as is discussed in Barbier and Burgess (1996) and later in this paper, agricultural expansion can be used as a proxy for deforestation in Mexico.

non-farm sector which may free labor from needing to tend extra land while at the same time stimulating alternate jobs off of the farms.

Bluffstone (1995) develops a household level model for Nepal that examines the deforesting behavior of smallholder agriculturalists as off-farm labor market conditions change. His model goes in depth into a household's deforesting behavior by including a large number of variables albeit in a rather restrictive model. He postulates that as members of these households earn more income from off-farm sources that they will buy alternative fuel sources to fuel wood (the gathering of which is a large part of his model for Nepal) and food grains to be cooked at home instead of using what is grown on site. These two things will cause the households to put less pressure on the forest as they must grow less food for their own consumption and will gather less wood from the forest for fuel wood. After running a number of different models he concludes that, under his restrictive model, off-farm employment opportunities are an important determinant of deforesting behavior.

The only paper that uses the idea of off-farm employment generated by economic growth as a result of foreign investment is by Coxhead and Jayasuriya (2003) where they investigate Thailand's economic 'boom' and the associated agricultural 'bust'. They use aggregate time series data to show that the labor intensive sectors of the economy (agriculture) became unable to compete with the rising wages in other sectors that were gaining more from foreign investment, such as manufacturing, generating a large decline in employment in agriculture, area planted, and agricultural output.

Overall, while there has been some connection made between FDI and deforestation, it has not made it into the main stream of the debate over FDI. However, many researchers have investigated areas that relate to this idea and back up many of the underlying concepts that connect FDI to reducing deforestation. The papers reviewed above were mentioned to give a sense of where the debate over FDI has generally been thus far and how deforestation has typically been analyzed.

III. Model

Linking foreign direct investment to deforestation necessitates drawing on a number of different theories on the allocation of labor, the impact of FDI on the labor market, and the relationship between agriculture and forest lands. These theories come together to form a two part model of how foreign direct investment ultimately affects croplands which can then be associated with deforestation.

The first part of the model deals with the FDI that moves into the economy and its interaction with the labor market. As can be seen in Table 1, approximately half of the FDI flowing into Mexico went to the manufacturing sector over the decade after NAFTA was formed. The next largest recipient during this time was the financial services sector which received 25% of total FDI. Comparatively only 0.2% of FDI went into agriculture and the rest was spread out into other sectors such as mining, utilities, construction, and hotels. This focused growth in terms of employment in the manufacturing and services sectors while others stayed relatively stable. The distribution of investment was also not even across the 32 Mexican states, with a large amount heading directly to the northern, more industrialized areas of the country and especially into the *maquiladoras*, or export assembly plants, which are located along the US-Mexico border. (Brown 2002; Hanson 2004) This uneven distribution can be seen in Figure 1 which shows the relative amounts of FDI that each state received in 2000.

Maquiladoras arose out of a softening of Mexico's import substitution strategy that allowed firms to import inputs and machinery needed for assembly of goods free of duties as long as they exported all outputs. At the beginning of the development of this specialized sector, maquiladoras were required to locate within 20 miles of an international border or coastline;

however this restriction was relaxed in 1972, allowing them to locate throughout the country. Due to this early restriction, most maquiladoras located along the US border and continued this even after 1972 because most goods assembled in these plants were intended for the US market. The structure of maquiladoras also allowed them to be the only firms in Mexico to be 100% foreign owned, which impacted the intensity of foreign direct investment in the states along the US border. While the formation of NAFTA ended the need for maquiladoras by ending the duties that had kept it restricted before, it did not end their growth. Labor in Mexico continued to be cheaper than in the US, allowing these assembly plants to still be very profitable for US firms even though the need for this specialized type of factory was no longer there. (Hanson 2004)

The growth in the manufacturing sector heavily stimulated the Mexican labor market, especially in the maquiladoras where labor was in high demand. Between 1990 and 2000, the Mexican census showed that there were over 2 million new individuals reporting employment in manufacturing, with every state except the federal district seeing an increase in manufacturing employment. Comparatively, agriculture only gained 368 thousand jobs, with 11 states seeing an overall decrease in the amount of agricultural jobs, many of these states being the same states that had among the largest increases in manufacturing jobs. This trend of decreasing employment in agriculture and increasing employment in manufacturing is assumed to be a result of an inter-sectoral labor market that has grown as FDI into manufacturing and services has increased wages in these industries relative to wages in agriculture.

The first part of the model for this study is developed to measure the affect that inward foreign direct investment has on a states' labor market. Specifically it looks at employment in agriculture and how it is affected by inflows of FDI, changes in wages between sectors, and measures of croplands and productivity. Underlying this model is the belief that FDI comes into a state it stimulates the sector of the economy for which it is intended and that this results in the creation of new employment opportunities in certain sectors along with a related increase in wages for the sectors that benefit most from the FDI.

Agricultural employment (AE) in a state is assumed to be a function of FDI, croplands (CL), agricultural wage (AW), wages in other sectors (OW), employment in other sectors (OE), price of maize (MP), emigrants out of the state (EM), and productivity (P):

$$AE_{it} = AE\,(FDI_{it}^{-}, AW_{it}^{+}, OW_{it}^{-}, OE_{it}^{-}, MP_{it}^{+}, EM_{it}^{-}, P_{it}^{-}),\ i = 1,\ldots, N\ \ t = 1,\ldots, T \qquad (1)$$

where superscripts indicate the *ceteris paribus* relationships as predicted by theory. Employment in agriculture is expected to decline with increased amounts of FDI. It is also expected that employment will decrease with lower wages in agriculture or higher wages in other sectors (particularly manufacturing and mining) as individuals presumably switch employment when off-farm employment becomes more profitable. It is expected that a decrease in the price of maize will cause a decrease in employment in agriculture as many small farmers will leave their farms as their returns are no longer as profitable as working in another sector. Emigration is expected to have a negative relationship with employment in agriculture as workers leave jobs on farms and the state to work in another state where sectors like manufacturing are stronger (such as the northern border region and the maquiladoras).

The second part of the model looks at the relationship between employment in agriculture and the amount of cropland in use. As it becomes less profitable to be employed in agriculture, individuals will look to other off-farm opportunities as these wages rise above those in agriculture and the returns to agriculture. This inter-sector movement of labor can be seen through the growth of jobs in sectors such as manufacturing along with the much smaller growth and even negative growth of agriculture in some states of Mexico. The loss of workers on farms will presumably translate into a decrease in the amount of croplands utilized, assuming that the workers are not replaced by an increase in productivity per unit of land through technological advancement. This section of the model however simply determines the basic relationship between agricultural employment and croplands by calculating the ratio of hectares of croplands to agricultural employees. This shows the approximate amount of land that one employee can work and therefore the expected amount of land that will be taken out of use when this employee moves to another state.

These two parts of the model come together to show the relationship between FDI, employment in agriculture, and the amount of land used for agriculture. The first part establishes a relationship between FDI and employment in agriculture, showing that FDI does affect the labor markets in Mexico, causing a shift between sectors. The second part of the model then establishes a link between this shift in employment and a reduction in the amount of land used for agriculture.

The available data does not allow a direct empirical test of the relationship between forest lands and croplands. However, the GIS data can be compared to see the areas in which forests lands have been changed into croplands as well as areas in which croplands have been abandoned and been reforested or changed into some other land cover type. This relationship has also been relatively well established in the literature. (Barbier and Brugess 1998; Anglesen 1999) While it has been pointed out that by no means is agricultural expansion an exact indicator of deforestation, it nonetheless has a relationship with forest lands that makes one able to associate changes in croplands with some amount of deforestation. Anglesen (1999) assumes that all cropland comes directly from forest, although he does add the caveat that this is not exactly accurate. As will be explored in more detail later, the GIS data for Mexico does in fact show that there is a relationship between croplands and forests, especially in southern Mexico.

Although these models attempt to capture the general trends that are affecting agricultural employment in Mexico, there are also a number of other factors not captured by the model that have had an impact on the make up of the agricultural and manufacturing sectors and the employment in these sectors. Table 2 shows the major policies in Mexico between 1985 and 1999 that have had affected the agricultural sector. Many of these policies have an effect that is opposite of that associated with FDI in the model. The Alliance for the Countryside and PROCAMPO, or the Program of Direct Support for the Countryside, especially have this opposite effect, encouraging farmers to stay on the farm and making it more profitable to be engaged in agriculture than it otherwise would be. The subsidies of PROCAMPO definitely will have an impact on the decisions of farmers and employees about whether or not to continue working on a farm or to move to another sector such as manufacturing. Although the present data set does not allow the affects of these policies to be studied, they nonetheless will have an impact on the change in employment as well as the amount of land that a farmer chooses to keep under use.

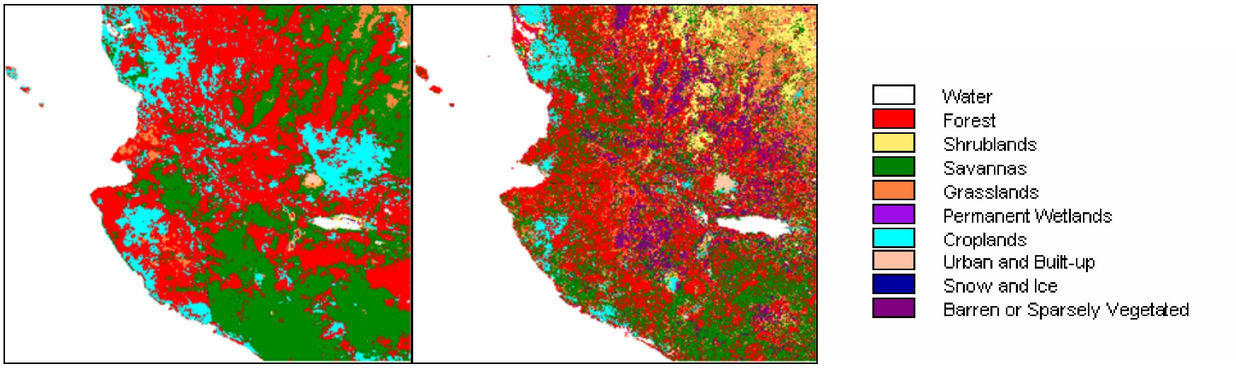
IV. Data

Deforestation data

Geographic Information System derived data

Data on deforestation and the amount of cropland being utilized comes from satellite images of Mexico that have been processed to show land use characteristics. Land is divided into 10 distinct categories: Forest, Shrublands, Savannas, Grasslands, Permanent Wetlands, Croplands and Cropland/Natural Vegetation Mosaic, Urban and Built-up, Snow and Ice, and Barren or Sparsely Vegetated. This classification system is a compressed version of the International Geosphere Biosphere Programme Land Cover Classification (IGBP) scheme that initially consists of 17 categories, but was compressed to 9 categories for the present study. The primary difference is that the original differentiates between forest types where as this study uses an aggregate of forest types.

This data is available for two points in time, 1993 and 2001. Unfortunately, land cover maps derived from one kind of satellite imagery do not exist for the specified time period, so data from two different satellites must be compared. (maps on page 46-47) The dataset for 1993 is derived from the 1-km Advanced Very High Resolution Radiometer (AVHRR) data and the dataset for 2001 is derived from the 1-km Moderate Resolution Imaging Spectroradiometer (MODIS/Terra Land Cover) product.



AVHRR data (1993) MODIS data (2001)

As can be seen in the above samples from each dataset, there are some noticeable differences between the two, however they are at the same resolution and use the same classification scheme making one able to compare them using GIS software. Furthermore research that has compared the two data products has shown that there is good agreement between the two and when compared directly the AVHRR data were associated with over 90% of the variation of the MODIS data. (Gallo et al. 2004) Much of the difference between the two datasets comes from the different methods by which the land characteristics were categorized. For the AVHRR data, it was processed primarily by people to classify each land cover class with the aid of reference data. (USGS 2003) MODIS, on the other hand, is done by feeding 'training sites' (sites that the land cover categories have been verified against past classifications such as AVHRR) through decision-tree classifier algorithms that then produce the global data after this training. This second method tends to be more accurate with an area-weighted confidence average of 78.3% compared to 66.9% for the AVHRR data. (Friedl 2003) This difference between the two sets of data must be kept in mind as it does introduce a source of error that could have an impact on comparing the two, although the evidence suggests that this error should not prevent the two from being compared in general.

For the purpose of this study both datasets were co-registered with each other and with a map of the Mexican states. This step was necessary because the maps for each set were produced with slightly different projections, so in order to accurately compare them with the state map overlaid; they needed to be projected in GIS to line up in the same way. The 17 categories of the IGBP scheme were then collapsed into the 9 categories listed above. Finally the area of land devoted to each type of land cover was extracted for each separate state using GIS. This yielded the area in hectares of the 9 land cover types that each state contains in each year.

Foreign direct investment data

Data on FDI was obtained from the Ministry of the Economy of Mexico. The Mexican government only has data on FDI by state for 1994 through the present. This is a result of a change in how they registered and accounted for foreign direct investment. For the time before 1994, rough data is only available on how much FDI flowed into a particular sector of the economy, but this data is not broken down by state. After 1994, any foreign investors were required to register with a national registry which compiles a fairly extensive collection of data on FDI into each Mexican state and the country in general. One point that must be kept in mind for the data on FDI in Mexico is that it is reported for the state in which the headquarters of a company is located and not necessarily where it was actually realized. For this reason the Distrito Federal has a much higher amount because FDI that is destined for other locations is registered at the headquarters of the company in Mexico City.

Census data

The Mexican censuses from 1990 and 2000 were used to obtain data on a number of demographic categories for each state. These data include employment and wages in agriculture and manufacturing as well as for construction, hotels, utilities, and mining. Employment was found by counting the number of individuals reporting employment in the industry and then applying the supplied weights for how many people in the population are represented by the respondent's characteristics. Wages were calculated using the weights and averaging the earned income reported by all non-employer respondents (except for agriculture where employers were retained to capture income by small farmers) for a particular sector. The census was also used to calculate the population of each state.

Intra-Mexican migration data was obtained from a question in the 2000 census that asked what state the respondent had resided in 5 years ago. Although many researchers have used this question for this information, it has been pointed out that this does not capture those individuals who have left and come back to their home state within the 5 year period. (Aroca and Maloney 2002) It also does not capture any seasonal migration that may occur between the states; however there are not many other sources that yield a somewhat accurate measure of migration within the country.

Productivity data

Information from the agricultural supplement to the *Encuesta Nacional de Empleo Urbana* was used to estimate an average level of technological advancement in agriculture. This was done by calculating the average output per hectare for agricultural lands that were reported. This data is available for 1996-2000 covering every state in Mexico.[2]

[2] The ENE has data available for 1991, 1993, and 1995, but these years do not cover every Mexican state and so were not used in the present study.

V. Methods and Results

There are a number of things that restrict what is possible for empirical analysis on the data for this subject. Both the data on deforestation and the data from the census are only available for two points in time. This restriction was also compounded because of the limit on the data on FDI. The first time period for data on land cover is in 1993, however, because of Mexico's change in the way that they account for FDI, this data is only available starting in 1994. This is also true for the census where the only two years available are 1990 and 2000[3]. Since FDI coming into Mexico in 1994 can have no bearing on the amount of forested land or croplands in 1993, there can be no true causal relationship drawn from these two variables in a straight panel analysis. A true causal relationship cannot be fully estimated between employment or wages in 1990 and FDI in 1994 when looking at how FDI affects these wages.

In order to deal with these restrictions, two models can be estimated. One model will look at the relationship that exists in 2000 when there are data available for all important variables. The second model will look at data that has been differenced between the available periods for the land cover data, the census data, and a number of other variables where the change over time is appropriate. The reason for considering this model is that it is less likely to be affected by unobserved state-specific factors that impact agricultural employment and are also correlated with FDI. For example, distance to the US border or any state-specific tax incentives that favor manufacturing and therefore negatively bias agricultural employment and also have a positive affect on FDI. This is then combined with averages of FDI over the available period to get a measure of the level of FDI received by each state between 1994 and 2001. This model is

[3] There is data available for earlier decades, but these fall outside the time period examined in this study.

not a true difference model since FDI data is not available for 1990. In fact, the average FDI between 1994 and 2000 appears to better explain the change in agricultural employment than does the difference between these two years. Even though this model is not a true pure differenced model it likely controls for unobserved time-invariant state-specific characteristics better than the model that estimates the relationship at the level.

Model Part One: Foreign Direct Investment and Agricultural Employment

Methods

The first part of the model is developed to establish a relationship between foreign direct investment and employment in agriculture, the goal of which is to show that the amount of FDI moving into a state has a significant affect on the employment in agriculture. This model is first estimated at the 2000 level where the original model can be written as a testable empirical model in the following way:

$$AE_{it} = \beta_0 + \beta_1 \ln(FDI_{it}) + \beta_2 CL_{it} + \beta_3 \ln(AW_{it}) + \beta_4 \ln(OW_{it}) + \beta_5 OE_{it} + \beta_6 \ln(MP_{it}) + \beta_7 \ln(EM_{it}) + \beta_8 P_{it} + \alpha_i + u_{it} \quad i = 1,\ldots, N \quad t = 2000 \qquad (3)$$

AE_{it} = employment in agriculture in state i in 2000
FDI_{it} = foreign direct investment in state i in 2000
CL_{it} = area of croplands being worked in state i in 2000
AW_{it} = average wage in agriculture in state i in 2000
OW_{it} = average wage in other sectors in state i in 2000
OE_{it} = employment in other sectors in state i in 2000
MP_{it} = market price of maize in state i in 2000
EM_{it} = emigrants from state i between 1995 and 2000
P_{it} = productivity (output/hectare) in state i in 2000
α_i and u_{it} = unobservable error terms

This model can also be specified using lagged values of FDI. Including these lagged values captures some of the temporal effects of FDI. FDI into Mexico in 2000 may not have a significant effect on employment in various industries in the same year in which it is recorded because it takes a certain amount of time for the investment to translate into a real change in a firm. In other words, it may take a year or two for an investment to be fully effective in altering the labor markets that are being studied. The model, when specified with one lagged value, becomes:

$$AE_{it} = \beta_0 + \beta_1 \ln(FDI_{it}) + \beta_2 \ln(FDI_{it-1}) + \beta_3 CL_{it} + \beta_4 \ln(AW_{it}) + \beta_5 OW_{it} + \beta_6 \ln(OE_{it}) + \beta_7 \ln(MP_{it}) + \beta_8 \ln(EM_{it}) + \beta_9 P_{it} + \alpha_i + u_{it} \qquad i = 1, \ldots, N \quad t = 2000 \tag{4}$$

This model was also estimated using larger lags, however these did not change the coefficients significantly from the one lagged value.

The differencing for the second equation requires a transformation of the above equations. The equation can be written as a testable empirical model with the differenced data in the following way.

$$\Delta AE_{it} = \beta_0 + \beta_1 \ln(\text{average } FDI_i) + \beta_2 \Delta \ln(AW_{it}) + \beta_3 \Delta \ln(OW_{it}) + \beta_4 \Delta OE_{it} + \beta_5 \Delta \ln(MP_{it}) + \beta_6 EM_{it} + \beta_7 \Delta P_{it} + \Delta u_{it} \qquad i = 1, \ldots, N \quad t = 1, \ldots, T \tag{5}$$

This equation allows the relationship between employment in agriculture and foreign direct investment during the 1990’s to be observed. It takes the average amount of FDI in the state and looks at how this relates to the change in employment in agriculture over the decade. This model will better represent the unobservable time invariant characteristics of states than equations (3) and (4).

Results

The results of running the three different regressions can be seen in table 4. These results support the conclusions that there is a negative relationship between foreign direct investment and employment in agriculture. All of the regressions except the 2000 level regression show that this relationship is significant. This lack of significance in the straight level model appears to be the result of a temporal effect associated with FDI as the level model with lags included shows. It appears that there is a delay on the effects of FDI on the labor markets of about a year. Higher lags were not found to be significant in this model. This is a result of the FDI taking time to work its way down into altering the functions of the firm into which it is invested and then altering their demand for labor.

The regression employing lags of FDI shows that when FDI is increased by 1% employment in agriculture will decrease by 758 the next year[4]. This has an elasticity of -.0043 meaning that a 1% increase in FDI for a given state over what it received in 1999 will, in one year, lead to a .43% decrease in agricultural employment in 2000.

Using the model that employs differenced data also shows a negative relationship between the variables. The coefficient for FDI in this regression is -23528[5]. This means that a sustained 1% increase in FDI will eventually result in 235 jobs lost in the long run (about 6 years). The elasticity associated with this coefficient is -.0013 which means that a 1% increase in the average of the FDI into a state over what it was between 1994 and 2000 will result in a .13% decrease in the change in agricultural employment.

[4] This is significant at the 5% level
[5] Significant at the 1% level

As can also be seen in Table 4, when the models use FDI as a share of the state's GDP, the negative relationship is maintained between FDI and agricultural employment. For the regression at the 2000 level this does not significantly change the coefficient; however it does change the coefficient for the partially differenced equation. This shows that when the amount of FDI that makes up a state's GDP has a sustained increase of 1%, employment in agriculture will decrease in the long run by 35 jobs or 0.0002%. This change is much smaller than that which results from the same regression using the average FDI for each state. This shows that there is most likely a bias caused by differences between states that affects how it absorbs the FDI once it enters into the state. States with larger economies most likely do not feel the same amount of stimulation that a state with a smaller economy does to the same amount of FDI. This will translate into different reactions that employment has to the amount of FDI.

It is interesting to note the positive relationship established between employment in agriculture and the emigrants from the state in each of the models. The regression employing lags shows that when there is a 1% increase in emigrants leaving the state, there are 123 more jobs in agriculture or a .69% percent increase[6]. This contradicts the relationship predicted by theory, but has interesting implications nonetheless. It was assumed that people emigrate for better work opportunities in other states, however one possible explanation for the estimated relationship is that the more productive workers in a state may leave to obtain work in a better paying industry in another state, however it would not be always possible to simply reduce the need for labor in agriculture by the same amount. If this is true, than employers may substitute the lost workers with less productive workers (i.e. younger or older workers) who are not as efficient, thereby resulting in a small increase in agricultural employment that is fueled by

[6] Significant at the 1% level for all regressions

emigration. This may also affect the decline in wages as workers may be paid less when they are less productive. This is one possible explanation for this relationship, but it is a question that cannot be fully answered given the currently available data on migration within Mexico.

Table 5 shows results when the above regressions are run using employment in manufacturing as the dependent variable instead of agricultural employment. The regressions do show the expected positive relationship between FDI and employment in manufacturing. This increase seems likely to be highly correlated with the decrease in employment in agriculture as individuals switch their employment from working on farms to various off-farm jobs, manufacturing being one of the most significant alternatives. These results however are not very strong since there are most likely a number of factors that influence FDI's impact on manufacturing employment that are not accounted for in the dataset. Therefore the magnitude of the relationship is not the important point, but rather that there does appear to be a positive growth associated with manufacturing at the same time that agriculture has negative growth. Overall this still does support the hypothesis that individuals are leaving employment in agriculture for things such as manufacturing as FDI comes into Mexico.

Model Part Two: Agricultural employment and Croplands

This part of the model looks at the functional relationship between agricultural employment and croplands. It specifically determines the ratio of croplands to agricultural employees in order to determine the amount of land that one employee can work. The mean of this ratio across the Mexican states is 2.63. This means that every employee is responsible for 2.63 hectares of land. However this relationship is not necessarily even across Mexico. As can be seen in table 6 there are large differences in the ratios between some states, with many having a ratio much smaller than the average between the states. Due to this difference, the effect of changes in agricultural employment will not be even across the states, with the states that have larger ratios having a much larger reduction in croplands than the states with small ratios. The differences between states is most likely a result of the type of crop being grown as well as how much capital is being utilized. Unfortunately the available data does not allow this to be explored in depth. This ratio also assumes that every worker in agriculture is actually adding to the productive capacity of the farm and that there are no other incentives going on in the economy that would alter this relationship.

This general ratio however does allow the affect that FDI has on agricultural employment to be connected with a change in croplands. As FDI pulls people out of employment in agriculture, this loss of employees then makes farmers reduce the amount of land that they have planted because they can no longer manage the same amount of land.

Model Part Three: Croplands and Forests

Given that a negative relationship has been established between the inflow of FDI and the use of croplands, the final connection needs to be made between croplands and deforestation. This relationship can be readily seen by comparing GIS data for Mexico. As can be seen in Figure 2, most forest land in Mexico is concentrated in the south and along the western side. Much of this area corresponds to where the higher concentrations of croplands occur (see Figure 3), making it likely that when these croplands expand, they will expand into forests. Figure 4 shows the areas in Mexico that have changed from forest into croplands between 1993 and 2001. As the map shows, there was a significant amount of forest land that was converted into croplands over the time period that was still being utilized as croplands in 2001. There is most likely a large amount that was converted from forest into croplands, but that had already gone out of use as cropland and been overgrown with another type of land cover between the times that the data was collected. It can also be seen that a large amount of this forest land conversion takes place in small amounts, especially well in the Yucatán Peninsula this can be attributed to small landholders that move to forested lands and cut down trees in order to establish new croplands from which they can grow crops for subsistence and to sell. The larger patches are most likely larger agricultural produces whose main focus would be producing crops to sell.

It was found in the GIS analysis that the total amount of croplands has actually gone down in a number of states. This land has subsequently been overgrown with another type of natural vegetative cover. This change can be seen in the Figures 5 and 6. These show the land that had been covered with crops in 1993 and have since been reforested or overgrown with another type of vegetation. There are also a number of areas that contain land that were croplands in 1993 and are barren in 2001 (as can be seen in Figure 7). These are areas that most likely were overworked croplands that can no longer grow anything since they have lost most of the nutrients in the soil. This evidence of a reduction in the amount of croplands being utilized holds with the theory developed in this study and reinforces the idea that the reduction in agricultural employment that has occurred in Mexico due to FDI has had the effect of reducing rates of deforestation.

Combining the models

The models can be joined in order to estimate the specific impact that foreign direct investment has on deforestation. As shown above, a 1% increase in FDI will decrease the change in agricultural employment by .13%. This means that a 10% increase in FDI, or about 52 million dollars per state[7], decreases the amount of new jobs available in agriculture by 2.3 thousand. Using the ratio of agricultural employment to croplands, this decrease in employment would mean, everything else being equal, a decrease in croplands of 6049 hectares. Although we were unable to estimate an exact relationship between croplands and deforestation, we can look at the upper-bound of the relationship to come up with an approximation for the largest affect that this increase in FDI could have on deforestation. If the relationship between croplands and deforestation one to one, a reduction in croplands of 6049 hectares would mean that the same amount of hectares of forest lands that possibly would have been deforested would remain intact or .000149% of the total forest land in Mexico in 2000. Since croplands and deforestation do not actually have a one to one relationship the real value will be somewhere below this figure. However, as long as there is in fact a relationship as discussed in the previous section, it appears that increases in FDI actually could translate into significant reductions in deforestation in Mexico.

[7] Which is much more FDI than some of the smaller and the southern states received in 2000.

VI. Conclusions

The objective of this study was to observe what impact foreign direct investment has on the economic decisions of the inhabitants of a host region and how this impacts their employment decisions and their use of forests. The results indicate that foreign direct investment affects labor markets in the host region in such a way so that it causes a preference to form for employment in other sectors of the economy rather than for in agriculture. This favoring of other sectors in the economy causes workers to leave jobs in agriculture for these other, more preferred jobs. As the workers leave the agricultural sector there is a reduction in the amount of croplands that are cultivated because there are no longer as many workers to work the land and it may be more profitable for some farmers, when they employ family members, to have part or all of their family work in off-farm jobs. This reduction in croplands can then be associated with a reduction in deforestation as there is less of an incentive to clear more forests for agriculture. If it is assumed that a reduction in croplands has a one to one relationship with a reduction in deforestation, than the results of this study indicate that a 10% increase in FDI will ultimately result in a reduction in deforestation of 6068 hectares. Although this is an upper-bound of what impact FDI could have, it nonetheless shows that it could have a significant impact on deforestation.

Although this conclusion appears to show the desired outcome of this study, there are a number of areas in which future research could improve upon the analysis that was undertaken. The restrictions presented by the data are the most important area in which further investigation can improve upon the present work. The data established the basic relationship outlined above, but there are many questions that it can not answer about the underlying mechanisms that impact the relationship between FDI and forests. One way to fix this problem is to collect a much more detailed dataset on something along the lines of a household level survey or a firm level survey. Firm level surveys would be able to better isolate the effects of FDI by comparing impacts of firms with FDI versus firms without FDI and how they impact inter-sectoral labor markets. An individual level survey that tracks more accurately the changes in the agricultural sector that occur when individuals switch their employment to another sector of the economy would help as well. This data would allow one to elaborate on the mechanisms that underlie the changes in agriculture that result when an individual leaves employment in agriculture for a job in a sector that has been stimulated by FDI. Also, the actual relationship between croplands and forest lands could be determined if data were to be examined from a single satellite in GIS. This is one area in which a study along these lines may have data available in the near future. The MODIS satellite used for the data in 2001 in this study is collecting data over multiple time periods and land cover maps are being maps are being derived for this stream of data. This data for multiple time periods from a single satellite will allow the data to be compared at a much more detailed level over time so that one can see more conclusively where land is changing between forests and croplands or croplands are going out of use.

There are also a number of policies that the Mexican government has enacted over the decade that have had a significant impact on the agricultural sector. Since the data in the present study did not accurately capture these policies, it would be recommended that future research into this topic be expanded to better account for these policy changes, especially the subsidies associated with PROCAMPO that began in 1994. These policies most likely have an effect counter to that which FDI was found to have in this study and may affect the final magnitude of the effect that FDI is found to have on agricultural employment and the amount of croplands that are being utilized.

With these recommendations for further investigation in mind, this study has achieved its main goals of establishing a relationship between FDI and deforestation and expanding the analysis of foreign direct investment's impact on the environment in the developing world. While most studies that have investigated this idea have focused on the negative aspects of FDI, this study has brought to light an aspect of FDI that seems to have positive effects on the environment or at least reduce the negative environmental affects of various economic activities. It allows the debate over the relative costs and benefits of FDI in the developing world to be slightly more balanced between the benefits for development and the costs that FDI may have on the environment.

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Appendix

Table 1

Realized Foreign Direct Investment

By Economic Sector [1/]

- millions of dollars -

SECTORES	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004 Jan.- Dec. Value	2004 Jan.- Dec. Part. %	Acum. 1994-2004 [2/] Value	Acum. 1994-2004 [2/] Part. %
TOTAL	**10,661.3**	**8,344.9**	**7,815.7**	**12,181.7**	**8,317.3**	**13,207.4**	**16,781.2**	**27,634.7**	**15,129.1**	**11,372.7**	**15,846.4**	**100.0**	**147,292.4**	**100.0**
Agriculture	10.8	11.1	31.8	10.0	29.0	82.5	91.8	49.3	7.1	-7.7	15.5	0.1	331.2	0.2
Mining	97.8	79.1	83.8	130.2	42.4	128.1	164.0	15.6	220.9	74.5	109.8	0.7	1,146.2	0.8
Manufacturing	6,207.2	4,858.2	4,814.7	7,294.7	5,156.8	8,993.7	9,501.5	6,031.5	6,499.9	5,044.8	8,246.1	52.0	72,649.1	49.4
RNIE	5,312.4	3,491.9	3,398.2	5,614.4	3,046.3	6,215.7	6,518.5	3,859.3	4,456.4	3,083.7	5,771.6	36.4	50,768.4	34.5
Investment in Maquiladoras	894.8	1,366.3	1,416.5	1,680.3	2,110.5	2,778.0	2,983.0	2,172.2	2,043.5	1,961.1	2,474.5	15.6	21,880.7	14.9
Water and Electricity	15.2	2.1	1.1	5.2	26.7	139.5	118.6	318.9	383.5	275.0	78.4	0.5	1,364.2	0.9
Construction	259.6	31.8	25.5	110.4	136.2	111.3	172.0	101.9	209.6	61.8	87.5	0.6	1,307.6	0.9
Commercial	1,251.3	1,011.5	727.2	1,933.3	971.7	1,258.4	2,305.3	2,211.1	1,581.2	1,088.8	891.6	5.6	15,231.4	10.3
Transp. y Comunic.	719.3	876.3	428.0	681.5	436.2	231.0	-2,262.2	2,944.6	797.8	1,683.2	1,236.7	7.8	7,772.4	5.3
Financial Services [3/]	941.4	1,066.1	1,215.2	1,103.4	729.4	760.4	4,767.3	14,413.8	4,439.1	1,967.3	4,740.6	29.9	36,144.0	24.5
Other Services [4/]	1,158.7	408.7	488.4	913.0	788.9	1,502.5	1,922.9	1,548.0	990.0	1,185.0	440.2	2.8	11,346.3	7.7

1/ Para el periodo 1994-1998, la inversión extranjera directa (IED) se integra con los montos notificados al RNIE al 31 de diciembre de 2004 y materializados en el año de referencia, más importaciones de activo fijo por parte de empresas maquiladoras con inversión extranjera. A partir de 1999, se incluyen además los conceptos de nuevas inversiones fuera del capital social, reinversión de utilidades y cuentas entre compañías que se han notificado al RNIE.
2/ Del 1 de enero de 1994 al 31 de diciembre de 2004.
3/ Servicios financieros, de administración y alquiler de bienes muebles e inmuebles.
4/ Servicios comunales y sociales; hoteles y restaurantes; profesionales, técnicos y personales.
5/ En congruencia con las prácticas internacionales, la suma de los porcentajes parciales puede diferir de los totales o subtotales correspondientes debido al redondeo que hace automáticamente la hoja de cálculo.
Fuente: Secretaría de Economía. Dirección General de Inversión Extranje

Table 2: Main Agricultural Policy Reforms in Mexico 1985 - 1999

Policy	Description	Years
Mexico joins GATT	• By 1990/91, most licenses to import agricultural products were abolished. In 1991-1994 most agricultural commodities were subject to tariffs fluctuating between 0% and 20%	1986/94
Institutional Reforms and the Government's New Role	• All State seed and fertiliters' companies were privatized. • State storage companies were privatized. • Elimination of all state companies involved in the commercialization of sugar, tobacco and coffee. • New institutions, such as ACERCA (1991) were created to give support and services to producers.	From 1988/89
Reform of the Agrarian Law	• Land redistribution ends • Guarantees freedom of choice and management to the ejido and its members • Recognizes the individual rights of each ejido • Members of each ejido can, if they wish: buy, sell, rent or use their lands as a warrant: when before they could only usufruct it. • The above makes commercial associations for ejidos possible	1992
North American Free Trade Agreement (NAFTA)	• Defines which are the obligatory conditions for market access and for export subsidies • Each country has the right to choose its own internal subsidies, phytosanitary measures, rules of origin and regulations for packing and tagging products. Each nation is responsible for making these rules as clear as possible, and must give exporters the opportunity to express themselves when regulations are changed. When rules change, reasons have to be scientifically demonstrated • Consistency with the WTO and with the Uruguay Round • Import and export licenses are abolished and substituted by tarrification • In 15 years, all tariffs will be eliminated by NAFTA members.	1994
PROCAMPO (Program of Direct Support for the Countryside)	• Direct payments to the producers of basic crops that compensates producers for the loss of input subsidies, price supports and import protection • Grants annual direct payments per hectare to those producers who continure to produce, based on historical acreage for nine crops • Works as a "security net" for rural income • Supports rural capitalization since it works as a guarantee for production • The program helps around 3.3 million producers, covering 14 million hectares	1994-2009
Elimination of producer price supports, abolition of CONASUPO (the National Company for Popular Subsistence) and creation of ASERCA for marketing supports to producers	• In 1991, guaranteed prices for wheat, sorghum, soy beans, rice, barley, safflower, sesame seed and sunflower were eliminated, and in 1999 support prices for beans and maize producers were abolished. • Prices of most grains began to be determined according to its international reference price • Supports for the marketing of wheat and sorghum • Since 1995, subsidies to grain producers to buy options at international markets in order to help mitigate risk	1991-1999
Alliance for the Countryside (Alianza para el Campo)	• A set of programs designed to support farmers with productive potential in an open economy • Its major goals are: to raise producer's income, to improve agriculture's balance of trade, to make food production grow twice as fast as the population, and to ensure the country's food security Federalized. Each state is responsible for the application of Alliance's programs. • Major programs: PROCAMPO, PRODUCE (realated to infrastructure and extension-type assistance and plague and disease control supports)	1995 onwards

Source: This table was directly reproduced from "My policies or yours: Have OECD agricultural policies affected incomes in developing countries?" where it appeared as Table 9 by Ashraf et. al. (2005) and was directly reproduced from "Lessons from NAFTA: The Case of Mexico's Agricultural Sector" where it appeared as Table 1 by Antonio Yunez-Naude (2002).

Table 3: **Variable Names, Definitions and Summary Statistics**

Variable	Definition	Mean	Std. Dev.
total1994	Total FDI in 1994 (Millions of Dollars)	333.166	1341.91
total1995	Total FDI in 1995 (Millions of Dollars)	260.778	795.323
total1996	Total FDI in 1996 (Millions of Dollars)	244.241	839.73
total1997	Total FDI in 1997 (Millions of Dollars)	380.678	1237.39
total1998	Total FDI in 1998 (Millions of Dollars)	259.916	722.438
total1999	Total FDI in 1999 (Millions of Dollars)	412.731	1082.59
total2000	Total FDI in 2000 (Millions of Dollars)	524.412	1471.12
lntotal94	Natural Log of Total FDI in 1994	4.99583	0.966969
lntotal95	Natural Log of Total FDI in 1995	5.07813	0.940968
lntotal96	Natural Log of Total FDI in 1996	5.01095	0.903335
lntotal97	Natural Log of Total FDI in 1997	5.10533	1.08328
lntotal98	Natural Log of Total FDI in 1998	5.07772	0.986062
lntotal99	Natural Log of Total FDI in 1999	5.21417	1.44563
lntotal00	Natural Log of Total FDI in 2000	5.38841	1.19921
avglntotalfdi	Mean of the Logs of Total FDI 1994-2000	5.16135	1.02519
agemp90	Employment in Agriculture 1990	165948	153947
agemp00	Employment in Agriculture 2000	177467	182403
dfagemp	Change in Agricultural Employment 1990-2000	11518.5	35797.8
manuemp90	Employment in Manufacturing 1990	143083	178425
manuemp00	Employment in Manufacturing 2000	206163	220972
dfmanuemp	Change in Employment in Manufacturing 1990-2000	63080.5	65781.2
mineemp90	Employment in Mining 1990	6354.38	8319.01
mineemp00	Employment in Mining 2000	6179.09	5120.89
dfmineemp	Change in Employment in Mining 1990-2000	-175.281	4133.12
agwage90	Nominal Wage in Agriculture 1990 (Pesos)	578456	210518
agwage00	Nominal Wage in Agriculture 2000 (Pesos)	2638.3	1541.73
lnagwage90	Natural Log of Wage in Agriculture 1990	13.2117	0.337096
lnagwage00	Natural Log of Wage in Agriculture 2000	7.75277	0.489799
dflnagwage	Change in Log of Wage in Agriculture 1990- 2000	-5.45892	0.290968
manuwage90	Nominal Wage in Manufacturing 1990 (Pesos)	721292	149914
manuwage00	Nominal Wage in Manufacturing 2000 (Pesos)	3198.69	1183.16
lnmanuwage90	Natural Log of Wage in Manufactruing 1990	13.4687	0.202992
lnmanuwage00	Natural Log of Wage in Manufactruing 2000	8.01657	0.319692
dflnmanuwage	Change in Log of Wage in Manufactruing 1990-2000	-5.45209	0.243373

minewage90	Nominal Wage in Mining 1990 (Pesos)	1.00E+06	548246
minewage00	Nominal Wage in Mining 2000 (Pesos)	3725.52	1648.38
lnminewage90	Natural Log of Wage in Mining 1990	13.7305	0.437287
lnminewage00	Natural Log of Wage in Mining 2000	8.13544	0.419836
dflnminewage	Change in Log of Wage in Mining 1990-2000	-5.59502	0.454194
emigrants9500	Emigrated into state in last 5 years 2000	99076.2	136585
lnemigrants00	Natural Log of Emigrants 2000	11.0377	0.881674
pop90	State Population 1990	2.50E+06	2.20E+06
pop00	State Population 2000	3.00E+06	2.70E+06
dfpop	Change in State Population 1990-2000	494760	560852
lnpop90	Natural Log of State Population 1990	14.4182	0.843804
lnpop00	Natural Log of State Population 2000	14.6163	0.806
dflnpop	Change in Log of State Population 1990	0.198119	0.102746
maize1990	Price of Maize 1990	619.463	70.3948
maize2000	Price of Maize 2000	1557.9	315.948
lnmaize90	Natural Log of Price of Maize 1990	6.42248	0.115518
lnmaize00	Natural Log of Price of Maize 2000	7.33469	0.176177
dflnmaize	Change in Log of Price of Maize 1990-2000	0.912218	0.153198
prod96	Agricultural Output/Hectare 1996	1.77843	1.21559
prod97	Agricultural Output/Hectare 1997	1.81138	1.18226
prod98	Agricultural Output/Hectare 1998	1.71446	1.08322
prod99	Agricultural Output/Hectare 1999	2.05486	2.11272
prod00	Agricultural Output/Hectare 2000	2.23201	1.5471
dfprod	Change in Output/Hectare 1996-2000	0.453575	1.03163

Table 4: Regression results for Model Part One. Dependent variable: Agricultural Employment (agemp)

	Regression at 2000 Level	Regression at 2000 Level with Lags	Partially - Differenced Regression	Regression at Level with Lags using Share of FDI in GDP	Differenced Regression using Share of FDI in GDP
avglntotalfdi			-23527.96		
			(2.94)**		
avgfdigdp					-3564.42
					(2.64)*
lntotal00	-13383.37	44600.52			
	(0.35)	(1.04)			
lntotal99		-75878.56			
		(2.31)*			
fdigdp00				26076.9	
				(0.52)	
fdigdp99				-73448.43	
				(2.28)*	
lnagwage	-6558.231	8975.764	-44651.69	1471.897	-48434
	(0.09)	(0.14)	(2.02)	(0.02)	(2.12)*
lnmanuwage	-37847.47	-70033.65	39583.79	-78378.43	15546.97
	(0.28)	(0.56)	(1.32)	(0.71)	(0.56)
manuemp	-0.273	-0.027	0.088	-0.066	-39405.7
	(1.53)	(0.14)	(0.89)	(0.38)	(2.78)*
lnminewage	-137968.4	-114112.9	-42008.42	-113730.9	0.016
	(1.92)	(1.72)	(3.01)**	(1.77)	(0.16)
mineemp	15.027	6.044	-0.213	5.514	-0.099
	(1.94)	(0.75)	(0.13)	(0.70)	(0.06)
lnmaize	-340401	-183065.4	26605.68	-183070.8	19354.6
	(2.11)*	(1.13)	(0.57)	(1.14)	(0.40)
lnemigrants00	154104	123025.9	21733	101566.4	4836.534
	(2.81)*	(2.37)*	(2.64)*	(1.93)	(0.49)
productivity	-1287.037	-13766.77	7109.35	-10869.41	3738.88
	(0.07)	(0.75)	(1.15)	(0.57)	(0.63)
Constant	2488351	1736792	-403005	1327096	-825652
	(1.72)	(1.27)	(2.51)*	(0.90)	(4.45)**
Observations	32	32	32	32	32
R-squared	0.71	0.77	0.58	0.77	0.55

Absolute value of t-statistics in parentheses
* significant at 5% level; ** significant at 1% level
Note: Since the model was estimated as a linear-log model, coefficients should be divided by 100 for interpretation

Table 5: Regression results for Manufacturing. Dependent variable: Manufacturing Employment (manuemp)

	Partially - Differenced Regression	Regression at 2000 Level with Lags
avglntotalfdi	42939.24	
	(2.05)	
lntotal00		-8187.78
		(0.17)
lntotal99		109458.6
		(3.17)**
agemp	0.793	0.186
	(1.99)	(0.88)
lnagwage	90027.13	58016.06
	(1.91)	(0.83)
lnmaize	-118458	-436818
	(1.26)	(2.90)**
lnmanuwage	-11808.3	-19301.6
	(0.18)	(0.14)
lnminewage	36767.53	-102132
	(1.06)	(1.36)
mineemp	1.779	20.431
	(0.47)	(2.73)*
emigrants9500	-0.092	0.698
	(0.68)	(2.53)*
prod	-10219.1	5046.078
	(0.76)	(0.23)
Constant	587246.3	3179558
	(1.60)	(2.07)
Observations	32	32
R-squared	0.42	0.8

Absolute value of t-statistics in parentheses
* significant at 5% level; ** significant at 1% level

Table 6: Ratios of Agricultural Employees to Croplands

State	Agricultural Employment	Croplands	Ratio
Aguascalientes	30176	10297.74	0.3412559
Baja California	75482	99378.17	1.316581
Baja California Sur	20173	599.8682	0.0297362
Campeche	55253	575473.6	10.41525
Coahuila	51615	113075.2	2.190742
Colima	36432	30493.3	0.8369923
Chiapas	626955	1435585	2.289773
Chihuahua	103332	40391.13	0.3908869
Distrito Federal	22401	5698.749	0.2543971
Durango	70952	22794.99	0.3212734
Guanajuato	217903	85481.23	0.3922903
Guerrero	255360	227450	0.8907035
Hidalgo	199201	243446.5	1.222115
Jalisco	252677	244646.3	0.9682174
Mexico	269408	46189.86	0.1714495
Michoacan	305932	64385.86	0.2104581
Morelos	78904	21695.23	0.2749574
Nayarit	89043	303833.3	3.412209
Nuevo Leon	50942	237147.9	4.655253
Oaxaca	456424	889004.8	1.947761
Puebla	500804	331427.2	0.6617903
Queretaro	43519	26694.14	0.6133904
Quintana Roo	35786	162964.2	4.553854
San Luis Potosi	161993	629761.7	3.887586
Sinaloa	242571	828917.9	3.417218
Sonora	127905	383415.8	2.997661
Tabasco	173061	1399093	8.084391
Tamaulipas	102175	1718523	16.8194
Tlaxcala	60605	15696.55	0.2589976
Veracruz	767929	3940135	5.130858
Yucatan	110965	558677.3	5.034717
Zacatecas	83064	24294.66	0.2924813
Mean	177466.94	459895.9118	2.63389521

Source: Calculated by author using employment data from Mexican Census 2000 and GIS data for croplands in 2001

Figure 1

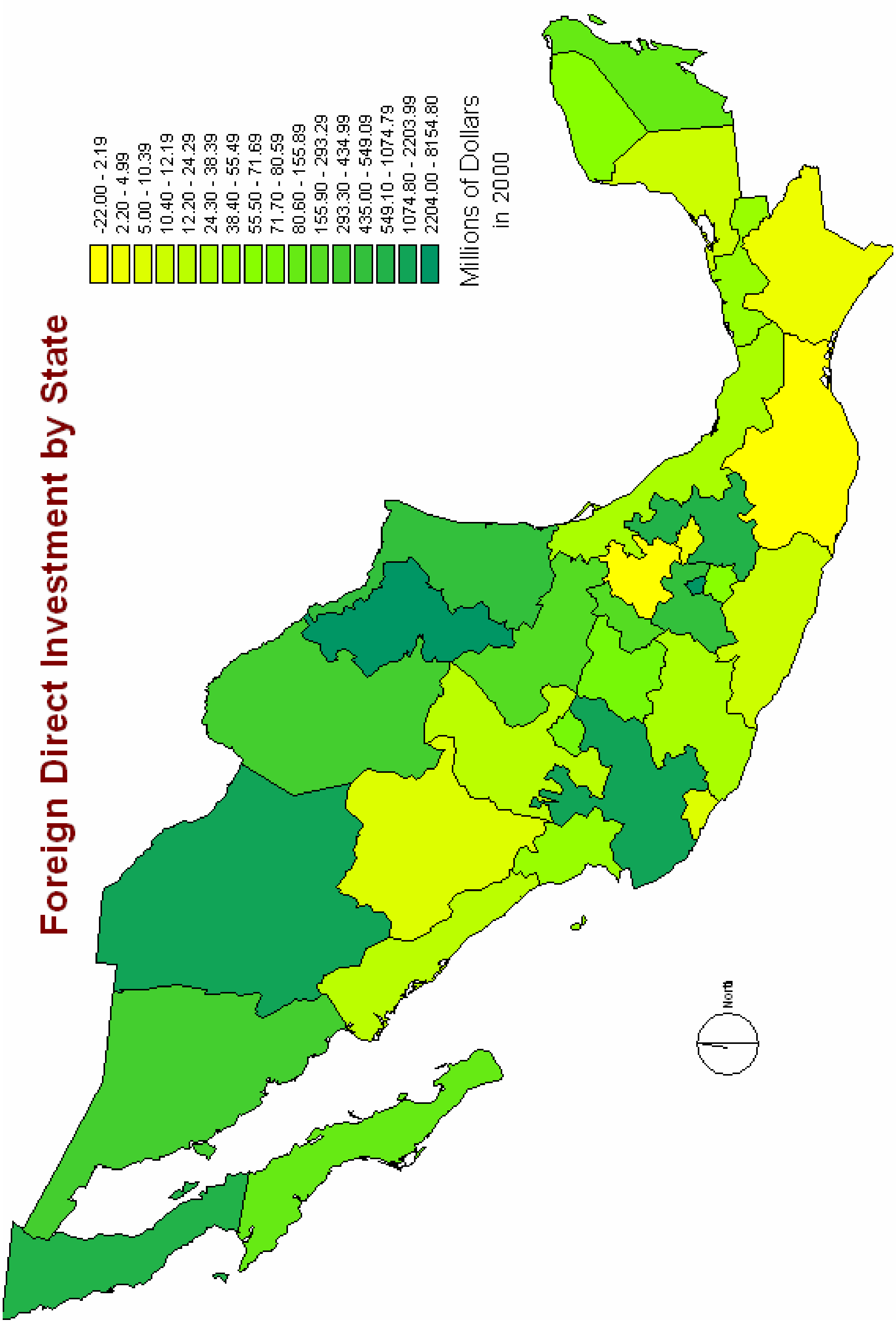
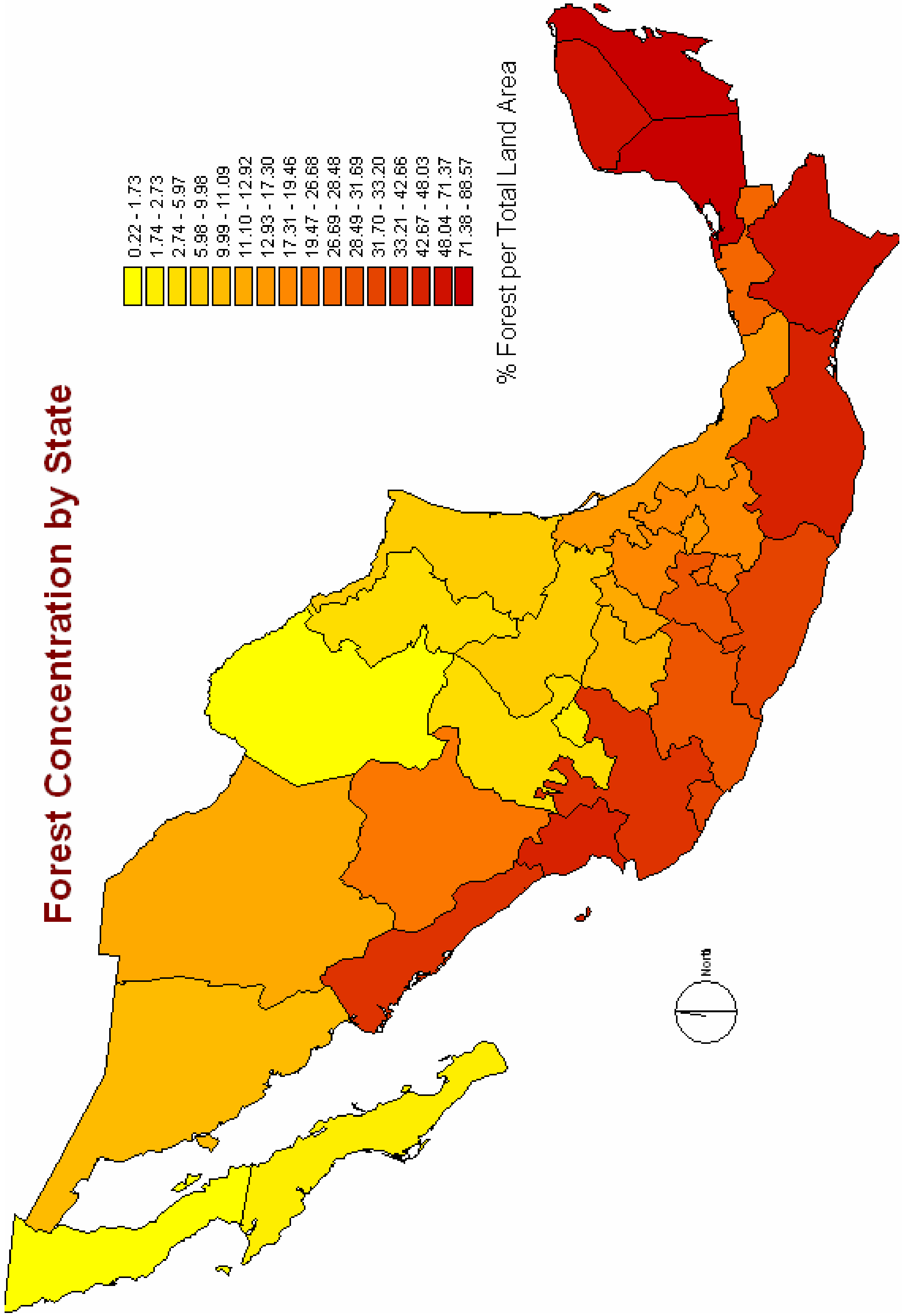

Foreign Direct Investment by State
-22.00 - 2.19
2.20 - 4.99
5.00 - 10.39
10.40 - 12.19
12.20 - 24.29
24.30 - 38.39
38.40 - 55.49
55.50 - 71.69
71.70 - 80.59
80.60 - 155.89
155.90 - 293.29
293.30 - 434.99
435.00 - 549.09
549.10 - 1074.79
1074.80 - 2203.99
2204.00 - 8154.80
Millions of Dollars
in 2000
North

Figure 2



Forest Concentration by State
0.22 - 1.73
1.74 - 2.73
2.74 - 5.97
5.98 - 9.98
9.99 - 11.09
11.10 - 12.92
12.93 - 17.30
17.31 - 19.46
19.47 - 26.68
26.69 - 28.48
28.49 - 31.69
31.70 - 33.20
33.21 - 42.66
42.67 - 48.03
48.04 - 71.37
71.38 - 88.57
% Forest per Total Land Area
North

Figure 3

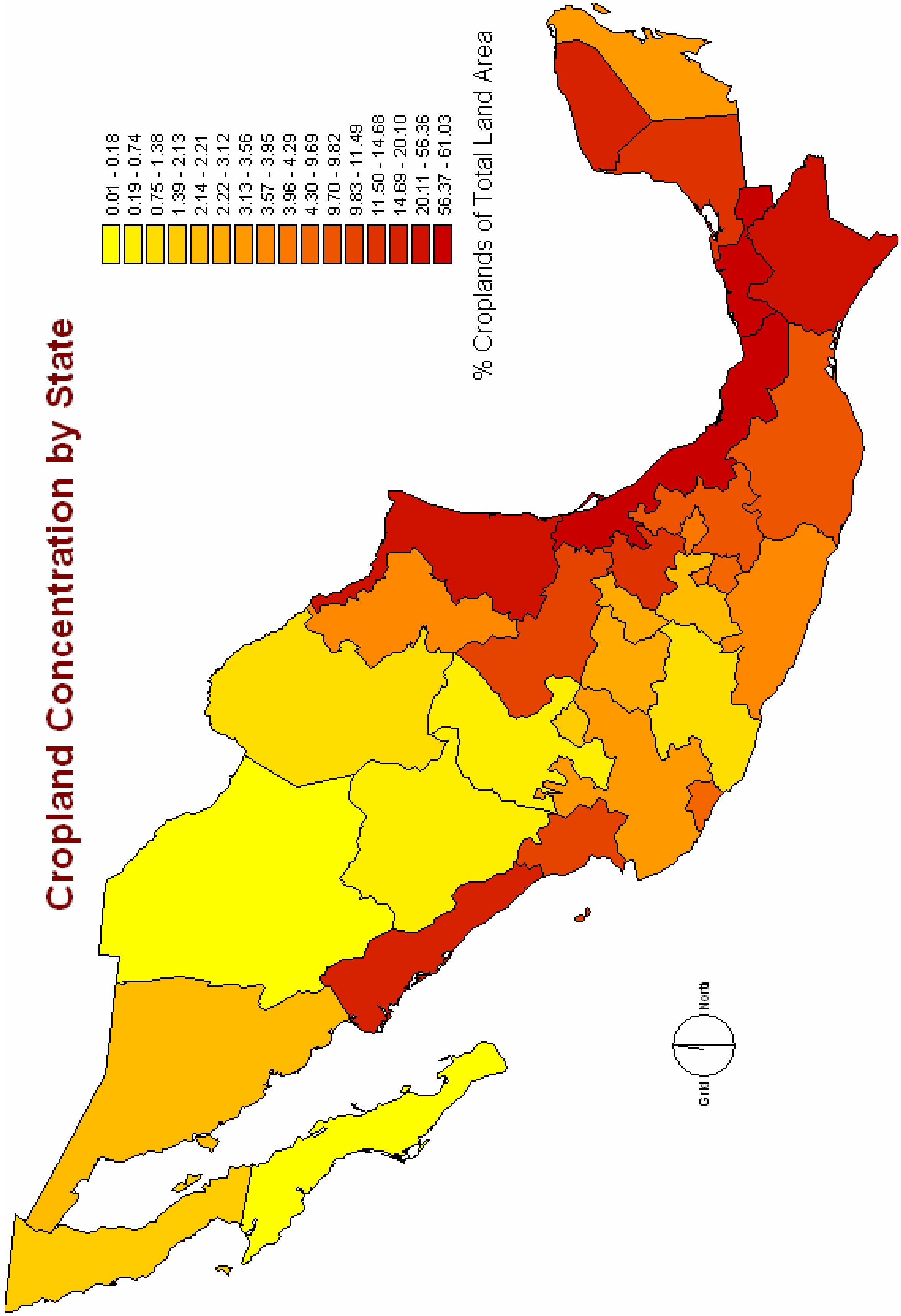

Cropland Concentration by State
0.01 - 0.18
0.19 - 0.74
0.75 - 1.38
1.39 - 2.13
2.14 - 2.21
2.22 - 3.12
3.13 - 3.56
3.57 - 3.95
3.96 - 4.29
4.30 - 9.69
9.70 - 9.82
9.83 - 11.49
11.50 - 14.68
14.69 - 20.10
20.11 - 56.36
56.37 - 61.03
% Croplands of Total Land Area
Grid North

Figure 4

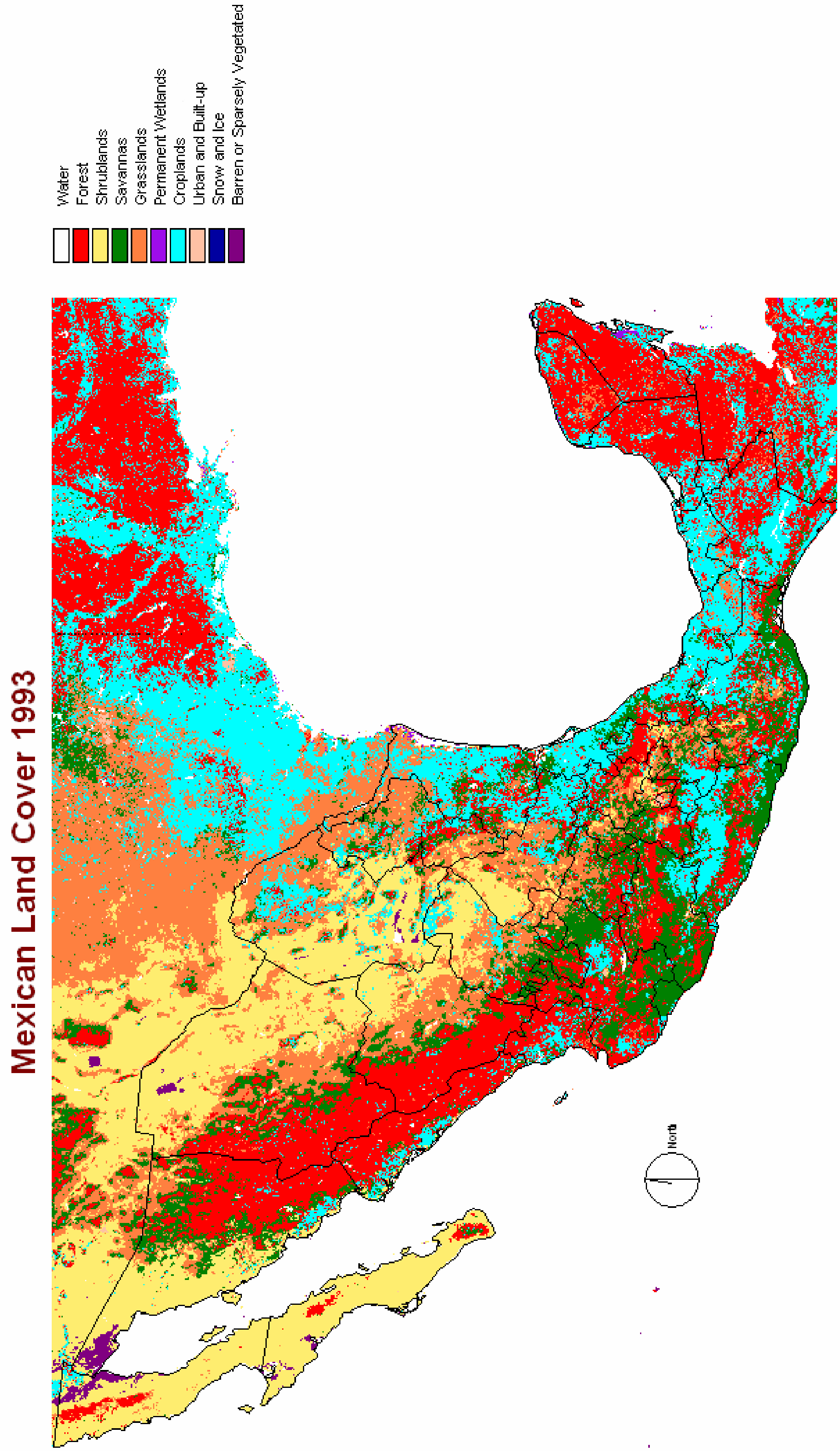
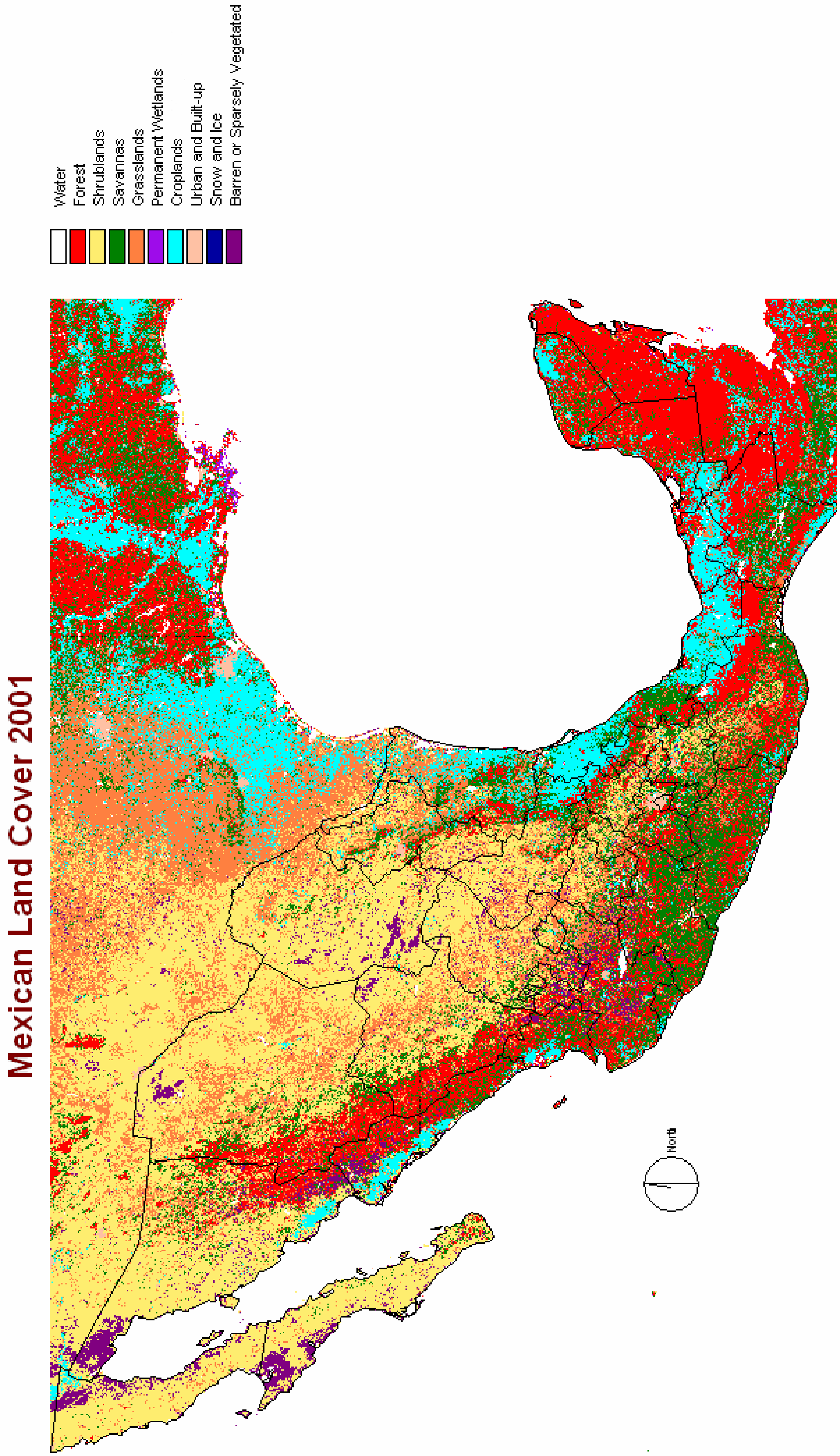

Mexican Land Cover 1993
Water
Forest
Shrublands
Savannas
Grasslands
Permanent Wetlands
Croplands
Urban and Built-up
Snow and Ice
Barren or Sparsely Vegetated
North

Figure 5



Mexican Land Cover 2001
Water
Forest
Shrublands
Savannas
Grasslands
Permanent Wetlands
Croplands
Urban and Built-up
Snow and Ice
Barren or Sparsely Vegetated
North

Figure 6

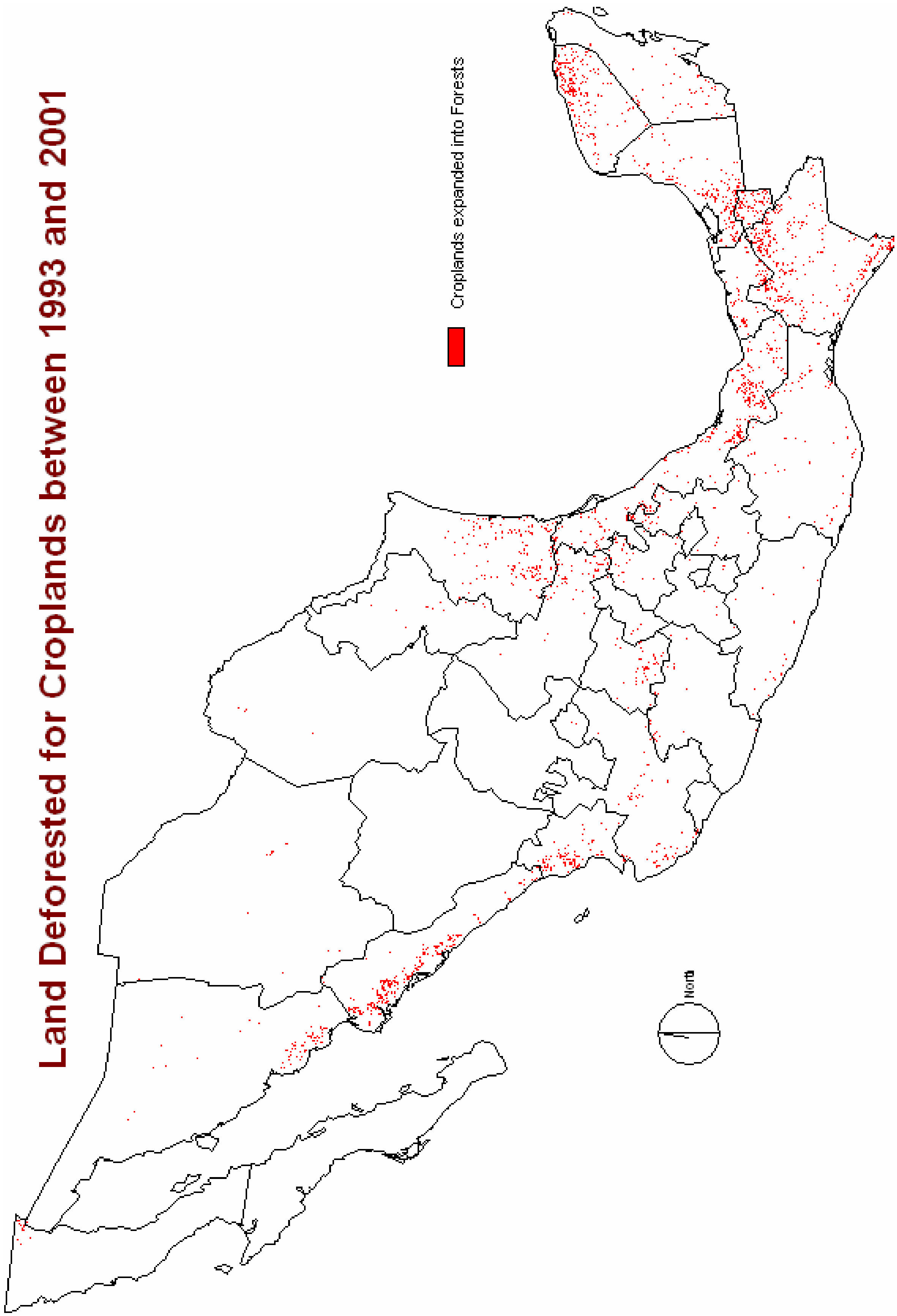

Land Deforested for Croplands between 1993 and 2001
Croplands expanded into Forests
North

Figure 7

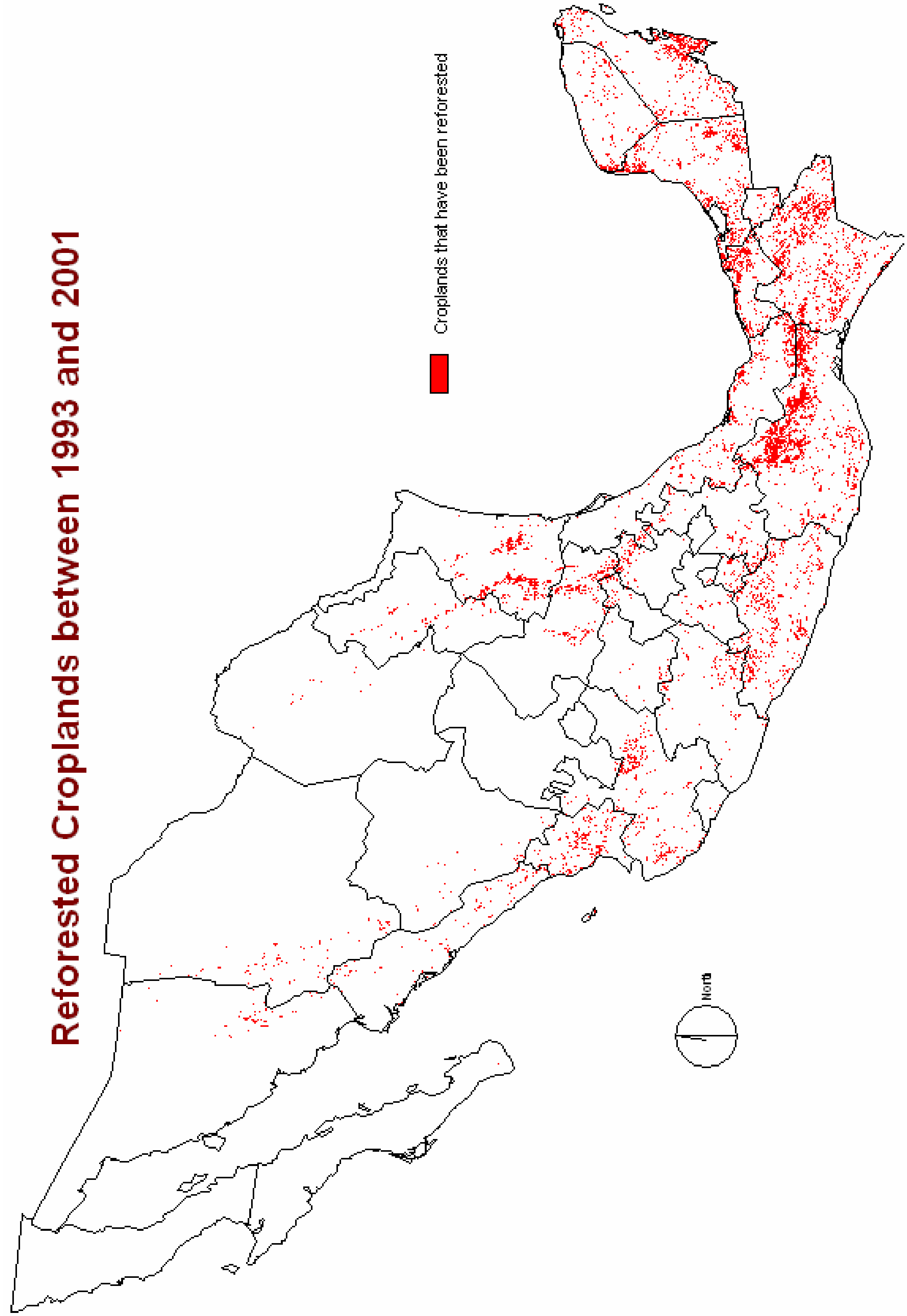

Reforested Croplands between 1993 and 2001
Croplands that have been reforested
North

Figure 8

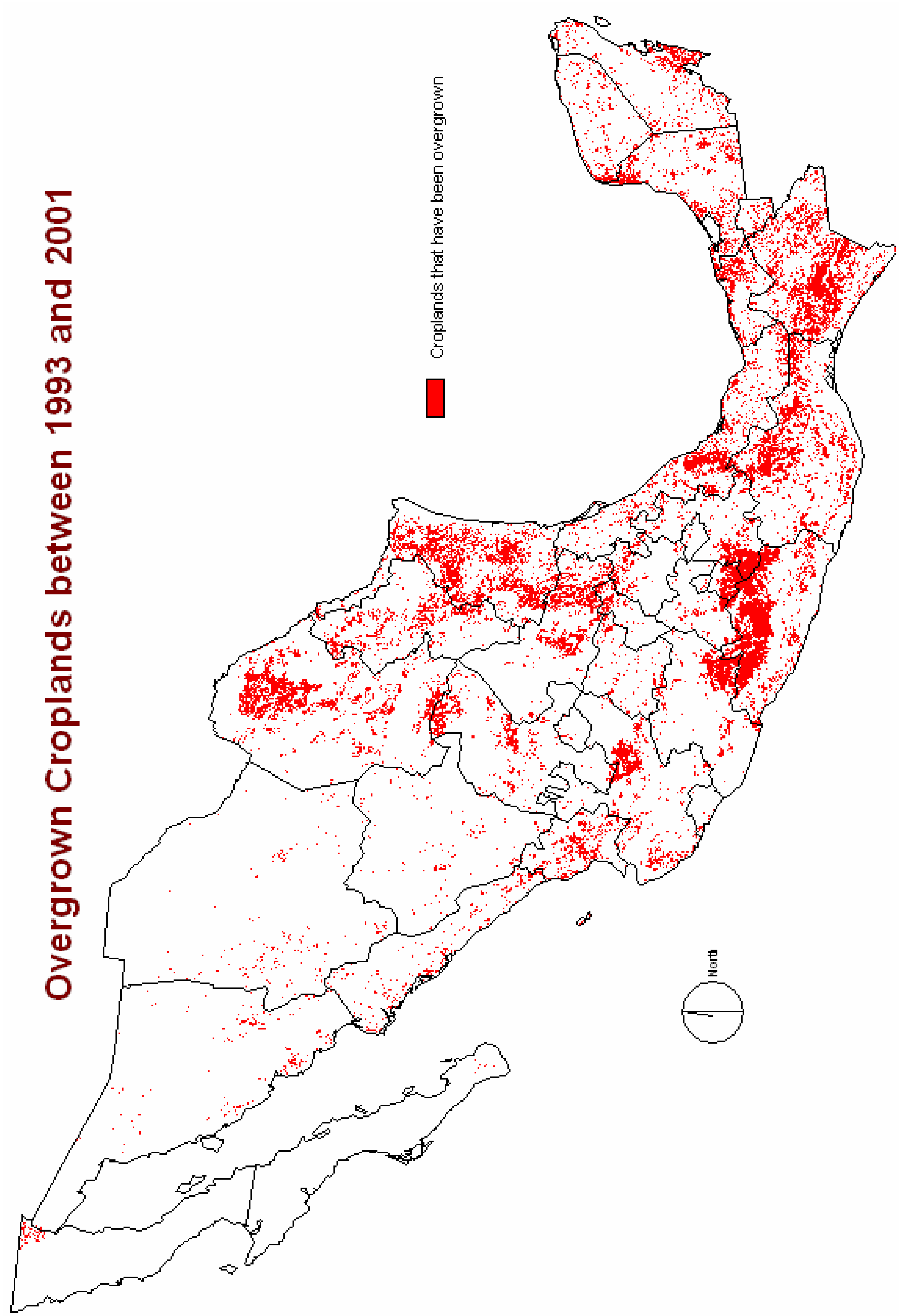
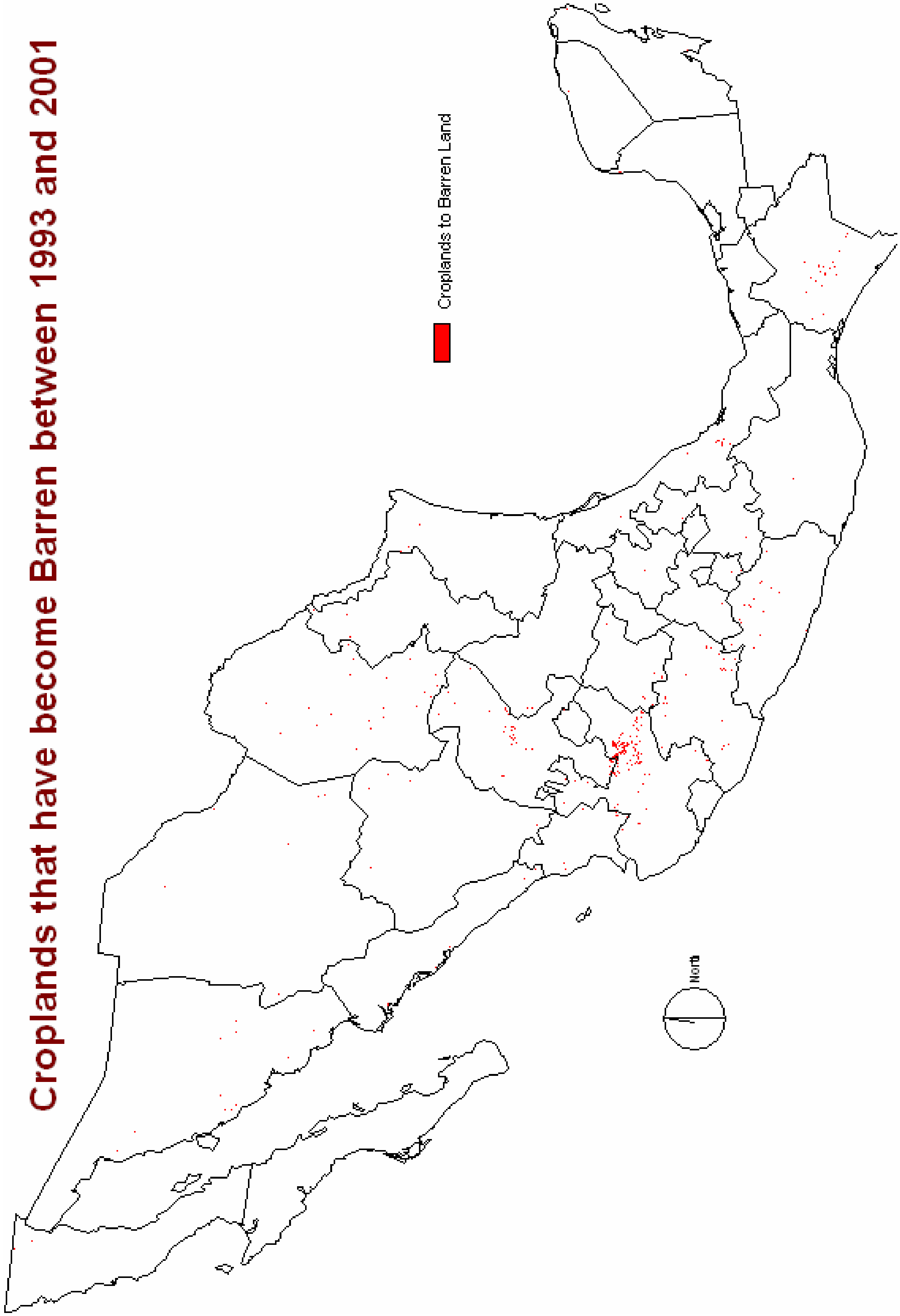

Overgrown Croplands between 1993 and 2001
Croplands that have been overgrown
North

Figure 9


Croplands that have become Barren between 1993 and 2001
Croplands to Barren Land
North