

# NAFTA, Agriculture, and the Mexican Environment<sup>1</sup>

Gerald C. Nelson  
Department of Agricultural and Consumer Economics  
University of Illinois, Urbana-Champaign  
October 1996

## I. Introduction

The environment became a major issue in the final negotiations of the North American Free Trade Agreement (NAFTA). The most vocal opposition came from several major U.S. environmental groups who feared NAFTA would worsen cross-border pollution and weaken U.S. environmental regulations. To accommodate these concerns, environmental agreements were added to the NAFTA negotiations.

There was little public debate in the U.S. about the broader environmental implications of NAFTA. Because the domestic effects of NAFTA in both Canada and the U.S. were expected to be small the environmental impacts likely also will be small. The potential for environmental effects was greatest in Mexico which had the smallest of the three economies and was scheduled to make the greatest changes in its economic policies as a result of NAFTA.

It is less than three years since NAFTA was concluded and implementation has just begun. The chances that observable environmental effects can be measured are small, even in the best of circumstances. More importantly, NAFTA was just one part of major policy reforms in Mexico. Since the mid-1980s, Mexico has joined the GATT, unilaterally lowered trade and other trade barriers, privatized large parts of the economy and made drastic changes in its laws regulating natural resources. The overall goal of these policies is enhanced efficiency of resource use and faster growth. However, these reforms have the potential for environmental changes much greater than those caused by NAFTA alone. In addition, the 1994/95 Mexican peso crisis had dramatic effects throughout the economy, swamping any observable short run effects of NAFTA. Finally, data on the environment are scarce in any country and Mexico is no exception.

This paper has several objectives. Since the environmental side agreements were the formal outcome of the NAFTA negotiations on the environment, a brief status report is presented. The main part of the paper focuses on how to disentangle the effects of NAFTA from other policy reforms, the (limited) empirical results that are available, and a new data set

---

<sup>1</sup>This paper was prepared for the Tri-National Research Symposium, "NAFTA and Agriculture: Is the Experiment Working?", San Antonio, Texas, November 1-2, 1996. Partial support for the research on this topic was provided by Cooperative Agreement 43-3AEM-3-880137 between the U.S. Department of Agriculture and the University of Illinois, Urbana-Champaign. The views expressed here do not necessarily reflect those of either institution.

that holds the promise of more accurate empirical estimates of the environmental consequences of NAFTA and other macroeconomic policy changes.

Since this conference is about NAFTA and agriculture, this paper focuses on the environmental consequences of changes in agriculture and natural resource use brought about by NAFTA. Even if the conference had a larger scope, however, the focus on agriculture would be appropriate. Although NAFTA may have environmental consequences outside of agriculture, the agricultural changes are likely to bring about the most widespread environmental effects. And many of the critical environmental issues facing Mexico arise in the agricultural sector.

## **II. Status of the Environmental Side Agreements of NAFTA**

When the Clinton Administration took office in 1993, the main NAFTA documents were essentially complete. In order to deal with the environmental issues raised during the election, and the opposition of several politically powerful environmental groups, the new administration decided to conclude two separate environmental agreements as part of the overall NAFTA framework. The North American Agreement on Environmental Cooperation (NAAEC) involves all three NAFTA countries and has a continental perspective on environmental issues. The other agreement, creating the Border Environment Cooperation Commission and the North American Development Bank, addresses U.S. - Mexican border environmental problems.

### ***North American Agreement on Environmental Cooperation (NAAEC) and the Commission for Environmental Cooperation (CEC)***

Negotiations between the three NAFTA countries on the NAAEC concluded in the summer of 1993. The agreement led to the creation of the tri-national North American Commission for Environmental Cooperation (CEC) based in Montreal, Canada. This new agency got off to a slow start, only getting a director in the fall of 1994 and being fully staffed in 1995.

The CEC is responsible for implementing the commitments of the three signatory governments to four sets of actions (see the CEC web site, [www.cec.org](http://www.cec.org), for more details):

- reporting on the state of the environment,
- striving for improvement of environmental laws and regulations,
- effective enforcement of environmental law, and
- publication and promotion of information.

Perhaps the most controversial of the CEC activities is its enforcement provisions under Section 14 of the NAAEC. The CEC Secretariat may consider a submission from a member country or any non-governmental organization or person asserting that one of the three member countries is failing to effectively enforce its environmental law. A process is specified for reviewing the submission with the possibility of it ultimately being brought to an arbitration panel.

As of October 1996, six citizen submissions had been made under Section 14 – two about U.S. environmental law, one about Mexican environmental law, and two about Canadian law. The two submissions on U.S. environmental law dealt with enforcement of the Endangered Species Act and the Salvage Timber Act. Both were rejected, basically on the grounds that the complaints were not about failure to enforce environmental law. The two Canadian submissions were about pollution of wetland areas degrading the habitat of fish and migratory birds and enforcement of the Fisheries Act and the Canadian Environmental Assessment Act. These were also rejected, on grounds similar to those for the U.S. cases. The submission from Mexican environmental groups is about whether an environmental impact assessment must be completed for a pier for tourist cruises in Cozumel being constructed in a protected natural area. This submission is still under review by the Secretariat staff (CEC Registry of Submissions).

***Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADBank)***

One of the environmental group concerns about NAFTA was the serious pollution along the U.S. - Mexican border and the potential for it to worsen under NAFTA. Serious border pollution problems include surface and groundwater pollution from untreated sewage and improper disposal of toxic industrial waste, and industrial air pollution. The border pollution is generated by the industrial concentration caused by the Maquiladora program, urban growth, and ineffective enforcement of Mexican environmental law. Since, the border population is expected to double in the next 20 years, the pollution problems will worsen unless remediation steps are taken now. Estimates of the cost to clean up the border range from \$8 billion by the Clinton administration to \$21 billion by the Sierra Club.

The governments of Mexico and the U.S. signed an agreement in November 1993 to help communities on both sides of the border carry out environmental infrastructure projects to reduce both urban and industrial pollution. Two institutions were established – BECC and the NADBank.

The BECC has its headquarters in Ciudad Juarez, Chihuahua, Mexico. The BECC has two important tasks. First, it helps local communities to develop infrastructure projects that reduce water pollution along the border (BECC does not fund projects to reduce air pollution). Second, it certifies projects for NADBank loans.

The NADBank is capitalized in equal shares by the United States and Mexico. It did not receive its funding until late 1994 and bank management was not in place until early 1995. In order to be eligible for NADBank loans, projects must be certified by the BECC.

In Figure 1, the locations of proposed projects submitted to the BECC in 1995 for consideration are indicated by stars. The three projects that received BECC certification in 1995 are indicated by a triangle (board and public outreach meeting are indicated by diamonds and circles). As of July 1996, an additional five projects had been certified, bringing the total to eight. These projects are a mixture of water treatment and reuse facilities. The total budget for all eight projects is about \$80 million. As of October 1996, two loans – for projects in Matamoros, Tamaulipas and Naco, Sonora – were in the final stages of approval and two more were expected to be completed by the end of 1996.

***Changes in enforcement of Mexican pollution regulations***

Concern was raised in the U.S. NAFTA debate about whether the Mexican government had adequate capability to enforce its environmental regulations. While not a part of any official agreement, the Mexican government agreed to enhance the enforcement of its regulations and has taken some steps to carry this out (ERS, 1996, p 32). The National Ecology Institute is evaluating 37 of its environmental standards in 1996 with the intent to emphasize overall environmental quality rather than command and control approaches for specific pollutants. Examples of these changes include:

- new water quality standards for emissions discharge determined by the type of water body (higher allowable pollution levels for flowing water than lakes and ponds), and
- new standards for toxic waste that would include pesticide runoff.

In 1995, Mexico’s Office of the Federal Attorney General for the Environment closed down 72 maquiladora firms on the U.S. Mexico border. It also suspended operations of 219 other firms.

***Summary of the Status of the Environmental Side Agreements***

It is too early to draw any conclusions about the effects of these agreements on the environment of any of the three countries. The slow start for both the CEC and the NADBank as meant that neither has had much effect to date. In addition, other economic events confound any effects of the NAFTA side agreements. For example, it was expected that NAFTA would ultimately reduce the desirability of the border location for industrial

Figure 1: Location of Projects Submitted to BECC, and Board and Public Outreach Meeting, 1995



production because the incentives provided by the maquiladora program would be eliminated. However, the peso devaluation and the resulting weakness in the Mexican economy meant that the border region became more attractive. Maquiladora employment increased 20 percent in the two years after NAFTA was signed (Public Citizen).

### **III. Theory of environmental consequences of macroeconomic policy changes**

The policy changes that make up NAFTA commitments of Mexico are only a part of the substantial policy Mexican reforms of the last 10 years. To sort out the effects of NAFTA on the environment, and in particular, the agricultural elements of NAFTA, we need a framework for modelling the environmental consequences of macroeconomic policy changes (see Munasinghe, et. al. for an approach similar to the one presented here).

An important conceptual problem in this analysis is to define environmental problems. The approach presented here differs somewhat from the typical approach in the literature (see Esty and the work reviewed there for examples). The notion of an environmental problem adopted here is conceptually identical to a negative externality. Varian's definition of an externality is "when the actions of one agent affect the environment of another agent other than by affecting prices" (Varian, p 259). Varian illustrates an externality with a fishery and a steel mill that pollutes the water. This example illustrates an important characteristic of externalities highlighted by Baumol and Oates – multiple users of a resource and less than full control over the resource by a single owner<sup>2</sup>.

Two conditions must be met for an environmental problem (externality) to exist. First, the use of the services of an environmental resource (defined below) must be profitable for more than one user. Second, this use must affect negatively other users of the resource.

Resources for which full control rights are not adequately defined are "environmental resources"<sup>3</sup>. Some environmental resources are well known. Examples include ground water

---

<sup>2</sup>Externalities are often classified by the effects on agents – for example, consumption externalities and production externalities. In each case, however, a resource with multiple users can be identified. An example of a positive consumption externality is a beautiful garden in someone's front yard. The environmental resource is access to viewing the garden. An environmental problem arises when too many passersby try to see the garden at once, blocking the views.

<sup>3</sup>Note that a sustainability problem can exist even if there is no environmental problem. The distinction is that an environmental problem involves "overuse" of an environmental resource (with ill-defined property rights) while a sustainability problem can occur on private property. For example, suppose a lake and its stock of fish have a single owner. It can make economic sense for the owner to reduce the stock of fish to zero if the owner's discount rate is high. However, since the lake owner owns the fish, and his use affects no other users of the

and the atmosphere. Others, such as the reservoir of beneficial insects in an area, are less obvious. Environmental resources are often attributes of more traditional resources. For example, an ecosystem is an environmental resource that can include privately-owned land.

The *effectiveness* of the control rights is key. Legal ownership of a resource does not necessarily translate into effective control. For example, a farmer (or a community) might have legal rights to a piece of land, but no mechanism to enforce those rights for certain attributes of the land. If there exists no effective mechanism to keep uphill erosion from the land, it is effectively an environmental resource from the perspective of erosion. Similarly, effective control can exist without formal ownership. Tradition rights to land often convey extremely effective control without the benefit of law.

Even if an environmental resource exists, an environmental problem is not a necessary outcome of its use. Neither of the two conditions for an environmental problem – use by more than one activity and negative external effects – necessarily holds at any given moment. Although the marginal cost of using an environmental resource is zero, by definition, the profitability of its use is not assured. Environmental resources that are not currently profitable include solar energy in space and zinc modules in the depths of the sea. Environmental resources that have only recently become profitable to exploit also can be found. Examples include parts of the electromagnetic spectrum, the krill stock in the Antarctic, and some tropical forest lands<sup>4</sup>. For a previously unused environmental resource, such as a tropical forest, to become profitable, the value of the product must rise, the costs of complementary inputs must fall, or the technology of use must change. Several different kinds of changes can make it profitable to use open-access tropical forest land to grow crops. Timber prices might rise. New roads in the region might lower the effective cost of ancillary inputs. More efficient forest clearing machinery might be developed. The opportunity cost of labor elsewhere in the economy might fall and make it profitable to grow labor-intensive crops in forest areas.

Even if an environmental resource is used, an environmental problem does not necessarily occur. Some environmental resources can provide productive services to all users, even at high levels of use. For example, it appears that the entire use of oxygen for breathing and release of carbon dioxide does not affect global warming. Other environmental resources can tolerate very little use. A single farmer who applies enough pesticides to

---

resource, this is not an environmental problem.

<sup>4</sup>In fact, an important part of the development process involves the development of effective control rights over more attributes of physical resources. A recent example is the delineation of exclusive rights to parts of the electromagnetic spectrum as “airwave pollution” reduced the value of the resource to all users.

contaminate ground water used for drinking has created an environmental problem<sup>5</sup>. Table 1 lists some resources used in agriculture that may have environmental problems.

Table 1: Examples of resources that are often environmental resources

<b>Environmental resource</b>	<b>Users</b>	<b>Affected users</b>
forests	timber, fuel wood and fodder gatherer; crop producer	current users; down hill agriculture; future generations
ecosystems	owners of land in the ecosystem	future generations
coastal breeding grounds	crop producer; fish and shrimp pond operator	marine resource user
irrigated soil quality	irrigation system	operator of affected farm
ground water	farm operator	ground water user
downhill agricultural resources	uphill farmer who generates erosion	downhill agricultural resource user (irrigation systems, farms affected by uphill erosion)

With the definitions of an environmental problem and an environmental resource, we can now turn to outlining a method of analyzing the effects of macroeconomic and trade policy changes on the environment. The essence of this approach is its focus on environmental resources. The macroeconomic goal of NAFTA is to reduce trade barriers to allow the three member countries to exploit more effectively their comparative advantage. From the perspective of a single member, the effect is changes in both micro and macroeconomic prices. At the micro level, output and input prices change for some goods. At the macro level, factor prices change, further altering production decisions. In addition, incomes change causing shifts in demand relationships.

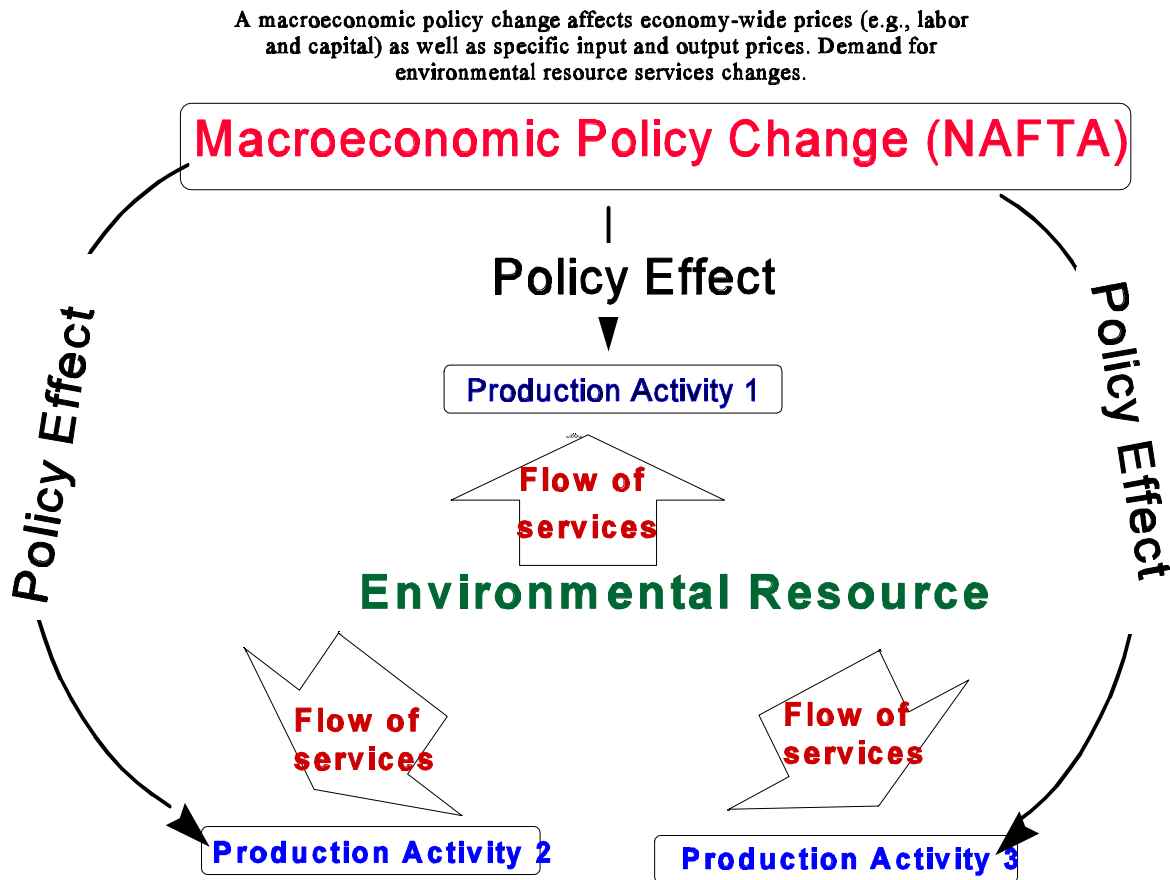
A trade agreement such as NAFTA can cause (or exacerbate) an environmental problem by making it profitable to begin “excessive” use of an environmental resource (Figure 2). It might raise the price of outputs produced using the resource, lower the prices of

---

<sup>5</sup>It is not uncommon for use of one environmental resource to affect other environmental resources. For example, deforestation of open-access forests can result in both degradation of downhill agricultural resources and loss of biodiversity. Excessive use of pesticides on private land can affect both biodiversity and worker health.

inputs used with the resource, or lower the opportunity costs of factors of production used with the resource. It is also possible for a trade agreement to *reduce* an environmental problem by making excessive use unprofitable. Without an empirical examination of the effects of a trade agreement or a structural adjustment program, unambiguous conclusions about environmental effects are not possible. It is possible that some environmental problems will improve while others worsen.

Figure 2: Environmental Consequences of Macroeconomic Policy.



With this conceptual framework, an analysis of the effects of Mexican policy changes, including NAFTA, on the environment involves four steps. The first is to identify important environmental resources and problems (potential or existing). The remaining steps should be undertaken for each environmental problem. First, identify the economic activities that use services from the resource. Second, identify the economic forces that affect each of those economic activities. Finally, measure the effects of the policy changes on those activities and the cumulative effect on economic services provided by the environmental resource.

#### **IV. Environmental problems involving agriculture in Mexico**

Mexican agriculture contributes to at least four serious environmental – surface water degradation, ground water degradation, a series of problems associated with deforestation (soil erosion, increased variability in stream flows, loss of biodiversity, loss of carbon sequestration), and ozone depletion. The first two are for the most part internal issues (except for transborder issues with the U.S.). Deforestation affects both the Mexican and global environment. Ozone depletion is a global problem.

##### ***Surface water and irrigation degradation (from Whiteford and Bernal)***

The irrigation infrastructure in the North, financed by the government, faces serious problems with salinization and water logging. More than 400,000 hectares are no longer planted because of salinity. The quality of streamwater throughout the country is threatened by erosion and pesticide contamination. The Mexican government has prohibited farmers in some locations from using river water for irrigation because of high pollution levels. Heavily polluted rivers include the Colorado, Panuco, Blanco, Lerma-Balsas, San Juan, Guayalejo, Culiacan, Coahuayana, Nazas, and Conchos (Albert in Whiteford and Bernal, p 224). In addition, stream flow variability in some rivers has increased as deforestation reduces water retention capacity.

##### ***Ground water degradation***

Agriculture contributes to two kinds of degradation of ground water – pollution with agricultural chemicals and depletion. For example, tests of well water in the Yaqui valley of Sonora showed the presence of certain pesticides at 5 to 10 times the rates regarded as safe by the U.S. Environmental Protection Agency (Bray). Overpumping of aquifers in some regions has drawn down aquifers, especially in the arid north.

##### ***Environmental Problems Associated with Deforestation***

Mexico ranks seventh in the world in terms of tropical forest area. It also has pine forests in the central and northern parts of the country. Mexico is losing its forests at 1.3 percent per annum by some estimates (Reed, 1992, p 87). Mexico is also rich in biodiversity. It has more endemic plants and vertebrates than the United States. Ownership of most Mexican forests is legally vested either in the state or ejidos, although after land and forestry law reform, private ownership of forests is possible. However, effective control is difficult (see Dewalt and Rees).

Deforestation contributes to at least four environmental problems. All users of products from open access forest are affected by excessive use. In addition, there can be a loss of productivity in downhill resources because of erosion and more irregular stream flow. Furthermore, a loss of biodiversity potentially can have negative effects worldwide. Finally, forests act as carbon sinks, reducing the amount of carbon dioxide in the atmosphere and slowing global warming. Hence, the rate of deforestation might be considered an indicator of four environmental problems rather than an environmental problem itself.

Deforestation in Mexico is caused by three distinct economic activities – expansion of food crop area, conversion of forest to pasture, and timber exports (see Barbier and Burgess). Although all three are important, existing data are not good enough to assign magnitudes to their effects. Two different phenomena can lead to deforestation for food crop production. When crop prices rise, production expands onto previously forested areas. When macroeconomic activity declines and unemployment increases, workers move onto marginal, open access lands in order to meet their food needs.

#### ***Ozone Depletion (based on Lynch)***

Methyl bromide is a soil fumigant, commonly used on fruits and vegetables to control soil-borne pests. It is also a Class I ozone depleter. Recent scientific evidence suggests that methyl bromide is 60 times more effective than CFCs at destroying ozone. The U.S. is unilaterally phasing out its production and use of methyl bromide by January 1, 2001. Mexico also uses methyl bromide production on horticultural crops, particularly in Baja California. As a signatory to the Montreal Protocol, it is presumably following the agreement that use will be frozen in 2002 and there will be a complete phase out by 2010.

## **V. Other Policy Changes that Influence Mexican Environmental Problems**

In addition to NAFTA, the Mexican economy has had several other important policy changes with potentially large environment effects. The PROCAMPO reforms replaced production-linked subsidies with direct income support to subsistence producers. Major changes were made to laws on land ownership, rural credit and banking, irrigation management, and forest regulation. Finally, the rapid devaluation of the peso in late 1994 and the resulting macroeconomic decline had potentially important environmental effects. This section summarizes these changes.

#### ***PROCAMPO***

PROCAMPO implementation began in October 1993. Support prices for maize, beans, wheat, sorghum, rice and soybeans, administered through CONASUPO and ASERCA, were to be phased out over 10 years. They are to be replaced with direct income payments to producers. These payments are to be based on historical acreage crop, theoretically divorcing them from current production.

#### ***Land ownership***

In 1992, Article 27 of the Mexican Constitution, which governs land tenure, was amended. Before the amendment, most agricultural land was owned communally by the members of the village collective or ejido (see, for example, Grindle). Individual members were given cultivation rights to certain plots. These rights were usually inheritable, but could not be transferred to nonmembers. Other ejido lands, for example some pastures and forest lands, were held communally. Any ejidatario could make use of these lands under restrictions determined by the ejido.

With the amendment to the constitution, the ejido system was modified. Ejido land is to be individually certified and titled, with ownership passing to the current operator. With certain limitations, ownership of ejido land can be transferred to individuals, including persons who are not members. These individuals would have the right to sell and use their land as collateral (see Council on Environmental Cooperation for more details). In addition, ejidos can engage in joint ventures with domestic or foreign firms.

***Rural credit (this section is based on Myhre)***

By the mid-1980s, official agricultural loans by BANRURAL were made to as many as 40 percent of all ejidatarios. These loans were almost always given in the form of a bundle of inputs (seeds and chemicals) provided at subsidized prices and with technical advice. In 1989, Mexican policymakers began a process of reforming the agricultural credit program. Subsidized interest rates were largely eliminated. The practice of lending to ejidos and other associations was replaced with lending to individuals. The use of individual plots as collateral, made legal under the land reform, began to increase. To determine credit-worthiness, a four-tier classification scheme was developed. Large commercial farmers who were already profitable were identified as good clients for the newly reprivatized commercial banks. Small and midsize commercial farmers and ejidatarios who were likely to be consistently profitable will also be serviced by the commercial banks. Loans to this group are backed by a state financial agency (Agricultural Trust Funds of the Bank of Mexico or FIRA). Next was a group of mainly ejidatarios who were less reliably profitable. This group is offered loans at a slightly subsidized rate by BANRURAL. The final group of over 1 million subsistence producers was deemed unable to manage formal credit. They receive loans from the National Solidarity Program (PRONASOL). Unlike the other groups, loans to this group of small producers can be made without collateral.

Accompanying the changes in credit practices, BANRURAL was reduced in size. The number of branch offices was halved and 62 percent of its work force was laid off. Between 1988 and 1994, the real value of its loans fell by about half and the area financed fell from 7.2 million hectares to 1.1 million hectares (Myhre, page 122).

These changes resulted in a dramatic restructuring of agricultural credit between 1988 and 1993. While BANRURAL credit declined, lending from other banks expanded. These other banks, however, are more likely to lend to large producers.

Table 2: Bank Credit for the Agricultural Sector, 1988-1993 (billion 1988 pesos) .

Year	Official Development Banks			Commercial Banks	Total
	BANRURAL	FIRA	Others*		
1988	3.98	2.53	2.91	4.41	13.83
1993	2.30	5.28	5.61	13.18	26.37

Source: Table 11.1 in Myhre.  
 \*Other development banks are Banco National de Comercio Exterior, Nacional Financiera S.A., and Financiera Nacional Azúcar.

PRONASOL was supposed to become the primary lender to small producers. However, as of 1993, it had not fully assumed that role. While the area covered by BANRURAL loans fell from 7.2 million hectares in 1988 to 1.2 million hectares in 1993, PRONASOL loans covered only 3.4 million hectares in 1993. Furthermore, PRONASOL loans were much smaller than BANRURAL loans had been. Hence, formal credit to small farmers was substantially reduced by the credit reforms.

Table 3: Area Financed by BANRURAL and PRONASOL Loans, 1988 - 1993 (000 hectares)

Year	BANRURAL	PRONASOL	Total
1988	7,234		
1990	1,952	1,987	3,939
1993	1,215	2,189	3,404

Source: Table 11.4 and Table 11.7 in Myhre.

These conclusions based on secondary statistics are borne out by a survey of ejidos conducted by de Janvry, et. al. In 1994, PRONASOL was the principal source of credit of small farms (less than 5 “endowment-adjusted” hectares), providing 77 percent of all credit received. For larger farms, on the other hand, PRONASOL provided 49 percent of all credit received and a variety of other sources (e.g., BANRURAL, commercial banks) provided the rest.

***Irrigation Policy (this section draws on Whiteford and Bernal)***

Mexican agriculture, especially commercial agriculture in the north, depends heavily on irrigation to maintain production. Only 27 percent of agricultural land is irrigated, but it accounts for more than 50 percent of production (Whiteford and Bernal, p 224). Over 50 percent of the irrigated land is in the northwestern states of Sinaloa, Sonora, Tamaulipas, Michoacán and Baja California. Until 1992, these irrigation districts were managed by the government.

In 1993, new legislation was enacted to transfer state-owned irrigation systems to the private sector. The goal was to enhance efficiency and financial self-sufficiency of the irrigation infrastructure. Before the law was enacted, the Secretariat of Agriculture and Hydraulic Resources (SARH) had responsibility for managing these systems. The Salinas administration created the National Water Commission (CNA) to develop and implement the new reforms for water management. Management of each irrigation district is being transferred to an association of water users. The association would have responsibility for maintaining the irrigation infrastructure through user fees.

A key provision of the reforms is that government subsidies for irrigation water would be eliminated, resulting in a substantial increase in cost to irrigation water users. At the end of the 1980s, users had been paying only 15 percent of the cost of water delivery. Beginning in 1994, they were supposed to pay 100 percent of the cost.

### ***Forestry Policy (this section draws on Wexler and Bray)***

Official forestry policy, and the degree of its implementation, have been undergoing more or less continue change since 1986. A major overhaul of forestry law in 1986 was intended to codify efforts to create a community forestry sector. Before this new direction could be fully implemented, however, official policy changed again. The new policy, expressed in the 1992 revision to forestry law and in conjunction with the land reform and related agrarian law, has two goals – to open ejido forests to private sector investment and to develop a forest plantation sector. The new laws and regulations have the potential for great changes in Mexican forests since 9,000 ejidos and indigenous communities control about four fifths of the remaining 50 million hectares of closed forest. Ejidos also control a much larger amount of degraded forest and scrub lands that are also subject to these reforms.

The 1992 reforms create a new category of ownership called forest smallholders, fix title boundaries, permit ejidatarios and comuneros to join in forest management and allow development of plantation forests of up to 20,000 hectares. Control of ejido common lands, including forests, can be transferred to corporate partnerships.

### ***Peso Collapse in 1994 and Resulting Macroeconomic Changes***

In December 1994, a run on the Mexican peso ultimately resulted in a dramatic devaluation. A large trade deficit in 1994 and an inadequate interest rate differential lead to a sudden upsurge in capital outflows. There were dramatic changes in macroeconomic prices and performance of the economy. Short term interest rates increased from 19% to 58%; the inflation rate jumped from 7 percent to 52 percent and GDP growth went from 3.5 percent to -6.9 percent (ERS, p. 5).

### ***Combined Effects of Reform Policies on Agriculture***

A common goal of the set of policy reforms enacted since the mid-1980s is to enhance the efficiency and productivity of Mexican resource use. Producers are more exposed to international and domestic competition. Public firms are privatized. Land ownership moves from communal management to private ownership. Irrigation systems move from state operation to private sector operation. Agricultural credit is to be provided by the private

sector. In many instances, this means an increase in price of agricultural inputs. In some cases, it also means a lack of availability in the short run, until private institutions are developed to provide the goods and services. Table 4 gives a qualitative evaluation of the effects of these reforms on the prices, and short run availability of institutions (access to credit) or inputs (fertilizer), brought about by these reforms.

Table 4: Qualitative Effects of Major Mexican Policy Changes Other than NAFTA.

<b>Agricultural input or output</b>	<b>Change in price</b>	<b>Short-run change in availability</b>	<b>Source of change</b>
Food crops	decrease		PROCAMPO
Forest product	increase		Forestry Law
credit	increase	reduced	Elimination of BANRURAL subsidy
Chemical inputs	increase	reduced	Elimination of BANRURAL technology packages
Irrigation water	increase	No change	Elimination of SARH subsidy
Crop land	Not clear	increase	Land reform

## **V. NAFTA-induced policy changes**

By opening Mexican agricultural markets and reducing support provided to the main agricultural commodities, NAFTA was expected to result in an overall decline in Mexican agricultural production. In addition, some observers feared that the reduction in Mexican tariffs on timber imports would destroy the community-based timber producers and processors (Castilleja and Goebel). For a few commodities, however, NAFTA was expected to result in higher Mexican prices and exports. Chief among these are horticultural crops where liberalization of U.S. import regulations would allow more sales to the U.S.

However, the dramatic decline in the peso in December 1994 made domestic support prices lower than world prices. U.S. farm exports to Mexico in 1995 were 22 percent lower than in 1994. The U.S. farm trade balance with Mexico was negative for most of 1995.

## **VI. Mexican Reforms and Deforestation**

We can use the theory presented earlier to provide a qualitative assessment of the combined effects of NAFTA and other reforms on the forest environmental resource. Three activities contribute to deforestation - crop area expansion (especially maize), logging, and conversion of forest area to pasture for cattle.

### **Crop Production Effects**

The combined effects of the Mexican reforms are widely predicted to reduce crop production. Output prices are expected to decline and fertilizer and credit prices to rise. If these were the only factors determining crop area expansion we would expect crop pressure on forests to diminish. However, the devaluation of the peso and the related macroeconomic depression, also depressed wage rates, reducing the opportunity cost of labor in crop production.

### **Logging**

The price effects of the reforms imply a decline in Mexican logging. Reduced tariffs on wood imports from the U.S. will lower profitability. However, the eventual privatization of forests may ultimately improve the profitability of timber extraction and increase logging.

### **Conversion to Pasture**

It is difficult to predict the effects of the reforms on cattle grazing. It is not clear how NAFTA will affect Mexican incentives to graze cattle in the south. In addition, land reform may make it possible to convert open access ejido lands that are currently not extensively used to private lands used for cattle grazing.

### **Summary**

This brief exercise in evaluating the effects of reform on deforestation is not meant to generate definitive predictions. Rather it is to illustrate that the set of Mexican reforms can have differing effects on activities that use services from an environmental resource. It also suggests the kind of analysis that would allow one to separate out the effects of NAFTA from the larger set of reforms.

## **VII. Selected Empirical Results to Date**

In this section, three studies that simulate the effect of NAFTA on the Mexican environment are summarized.

### ***CGE Models of Aggregate Effects***

In a series of papers written based on work for the OECD's research program, Sustainable Development: Environment, Resource Use, Technology and Trade, John Beghin and his coauthors use a CGE model to simulate the effects of NAFTA reforms on the Mexican environment. Production and consumption of goods is assumed to generate toxic pollutants that end up in water, air and on land. Following Grossman and Kruger, a change in pollution levels has three sources – composition (changes in the mix of final goods produced), technology (changes in production technology) and scale (changes in aggregate economic activity). In a 1995 paper, they simulate NAFTA type reforms with trade distortions expressed as ad-valorem equivalents and reduced to zero by 2010. With no change in pollution abatement, real GDP rises by 3.2 percent and all major pollutants increase by the about the same amount (Beghin, et. al., 1995, p 781). Agriculture contracts by 2.4 percent.

A more recent study has more detail on the agricultural sector, including crop-specific contributions to pollution (Beghin, et. al., 1996). The decline in aggregate agriculture output is somewhat greater than that in the earlier simulation. Much of this decline comes from large declines in production of staple food and feed crops (maize, beans, barley and soybeans). The commodity-specific declines in output lead to roughly corresponding declines in commodity-specific emission of water pollutants. However, emissions of soil pollutants decline much more than output declines for soy beans and much less for wheat and barley.

### **Effects of NAFTA on Horticulture in Sinaloa**

Abler and Pick estimate supply response parameters for horticulture crops grown in Sinaloa using data from 1967 to 1987. They then use estimates of the long run effects of NAFTA on prices to simulate how horticulture production will change. They assume that NAFTA will lead to a 10 percent increase in output prices and a 10 percent decline in prices of competing commodities (wheat, maize, beans). They find a 50 percent increase in horticulture area, and 14 percent increase in a technology variable. They argue that since horticulture production in this area is relatively low in chemical use, the environmental consequences of this area and technology expansion will be small.

### ***Effect of NAFTA on Mexican Use of Methyl Bromide (this section is based on Lynch)***

A recent study by Lynch can be used to examine the possibility that NAFTA would increase the Mexican use of methyl bromide. Lynch simulates the effects of the U.S. ban on methyl bromide using synthetic production technologies and a price/quantity endogenous model for strawberries and tomatoes. For tomatoes, she finds that the ban would increase prices by 7.3 percent. Mexico grower would increase their production by almost 80 percent, but Mexican use of methyl bromide on tomatoes would increase only slightly. For strawberries, Mexican production would increase after the ban, but Mexican use of methyl bromide on strawberries would also not increase much. These results reflect the production characteristics in the main producing regions in Mexico. In Sinaloa, the soil type is such that methyl bromide does not increase yields. Growers will expand acreage to increase production. Baja producers do use methyl bromide, but are constrained by water scarcity. Since the production effects of NAFTA are similar to those of the U.S. methyl bromide ban, we should not see much expansion of methyl bromide use from NAFTA.

### **Summary of these studies**

These studies have several common features. First, they focus on chemical pollution of land and water resources from agricultural production. Other potential environmental problems are not considered. Second, external effects are implicit; no attempt is made to measure the external effects of the pollution. Third, all are constrained by lack of data. For example, Beghin et.al. use country-wide estimates of the contribution of a crop to pollution. Yet, it seems likely that commercial crop production in one region will use polluting chemicals more intensively than small-scale crop production in a different region.

## **VI. Satellite Images: A New Data Source for Analysis of Environmental Problems**

As the studies reported in the previous section show, any attempt to estimate empirically the environmental effects of NAFTA and other policy changes in Mexico rapidly confronts the paucity of data on the environment. For example, the FAO land use data set shows forested area remaining constant for long periods punctuated with periodic spikes. Without reliable data on environmental variables, estimation of environment effects of policy changes will be indirect at best.

A data source not hitherto used by economists promises to improve some environmental data. Satellite images seldom have been exploited for economic analysis of environmental problems although many environmental problems are visible on the surface of the earth (see Nelson and Hellerstein for an example). Examples include deforestation, destruction of mangrove swamps, salinization of agricultural land, and erosion. In this section, some advantages and disadvantages of using satellite images are discussed.

A satellite camera record electromagnetic radiation reflected from the surface of the earth (or clouds). Since vegetation, water, soil, and urban areas absorb and reflect different frequencies, a judicious choice of recorded frequencies makes it possible to distinguish among different types of land cover. The basic element of a satellite image is the picture element or pixel. Depending on the geometry of the camera, a pixel captures light from an area as small as 5 meters square to as large as sever square kilometers.

Three types of images are widely available - MSS, TM, and AVHRR. MSS images were taken from the multispectral sensor aboard Landsat satellites three, four, and five. Each image covers an area of approximately 100 km by 100 km. Each pixel in the raw data records reflectance information from an area 100 meters by 100 meters. Each image has four bands of information, corresponding to reflected light in the green and red frequencies and two near infrared frequencies. A 4-band MSS image is about 65 megabytes. MSS images are available from the early 1970s to the early 1990s.

TM images are taken from the thematic mapper sensor aboard Landsat satellites four and five. TM images can have as many as seven bands. Several TM bands are similar to those of the MSS images. However, the spatial resolution of the raw data is 30 meters by 30 meters. Each image covers an area of 150 km by 150 km. A 7-band TM image is over 300 mb in size. TM images are available from the mid 1980s.

AVHRR (advanced very high resolution radiometer) images are taken by the ITOS satellites, operated by the National Oceanographic and Atmospheric Administration. AVHRR images have four bands, as do MSS images. However, both the reflectance frequencies and spatial resolution differ. A pixel represents a square 1.1 km on a side, approximately 140 times larger than an MSS pixel. An AVHRR image is about 800 km on a side. AVHRR images are available from the early 1980s.

Since both TM and MSS sensors are carried on the same satellite they have the same temporal frequency. The Landsat satellites pass over a given spot on the earth every 16 days

in mid-morning. AVHRR images are potentially available much more frequently. The satellite passes over a given location twice a day.

Satellite images can be used to identify vegetative cover because chlorophyll has a distinctive reflectance signature. However, to make best use of satellite images, especially in a time series context, they must be georeferenced. This process involves identifying a precise geographic coordinate for each pixel. Georeferenced images can be combined with many different kinds of information in a geographic information system. For example, it is possible to identify pixels whose vegetative cover has changed from period to period. If digital elevation information is available, elevation and slope can be computed for each pixel to provide information on potential for erosion. Information on soil type and precipitation can be added to further refine estimates of erosion potential. Unfortunately, early satellite images were not originally georeferenced. The EROS Data Center has almost completed a project to provide a consistent georeferenced MSS coverage of the U.S. and Mexico for three periods - the mid 1970s, the mid 1980s, and the early 1990s.

## **IX. Conclusions**

Implementation of NAFTA, whether the official agreements involving trade and investment liberalization or the environmental side agreements, has just begun. Many of the trade liberalization measures are phased in over a long period. The institutions set up by the environmental side agreements - CEC, BECC, and the NADBank - only became fully operational by the end of 1995. Hence, it is too early to expect any observable environmental consequences of NAFTA, good or bad.

Mexico is the country where we might expect to find the largest environmental effects of NAFTA. Its policy changes arising from NAFTA are the largest of the three countries. But the NAFTA reforms are a relatively small part of a larger set of economic reforms in Mexico with the goal of enhancing resource use. Large parts of the Mexican economy are being privatized. Laws governing land ownership, forests, irrigation, and credit have all been recently changed. The cumulative effects of these changes on the Mexican environment are likely to swamp any NAFTA effects.

The limited empirical research undertaken to simulate the environmental effects of NAFTA has found only small changes. In addition, these studies have significant limitations. Chief among them is a lack of reliable data on environmental problems. This paper has proposed that a new data source - satellite images - can be used to address some of the data limitations. Anything that can be observed from space potentially can be quantified from satellite images. The use of this data source for economic analysis is in its infancy, but as availability improves and processing costs fall, the satellite images will significantly improve evaluation of the effects of NAFTA, and other macroeconomic policy reforms, on the environment.

## References

- Abler, David G. and Daniel Pick. "NAFTA, Agriculture, and the Environment in Mexico." American Journal of Agricultural Economics 75 (August 1993):794-798.
- Albert, Lilia. "La Contaminación de los Recursos Hidráulicos en Mexico." in Ivan Restrepo, ed. Agua, Salud, y Derechos Humanos. Mexico City: Comision Nacional de Derechos Humanos, 1995.
- Barbier, Edward and Joanne Burgess. Economic Analysis of Deforestation in Mexico. Department of Environmental Economics and Management, University of York, 1994. Discussion Papers in Environmental Economics and Environmental Management 9406.
- Beghin, John, David Roland-Holst, and Dominique van der Mensbrugghe. "Trade Liberalization and the Environment in the Pacific Basin: Coordinated Approaches to Mexican Trade and Environment Policy." American Journal of Agricultural Economics 77 (August 1995): 778-785.
- Beghin, John, Sabastien Dessus, David Roland-Holst, and Dominique van der Mensbrugghe. The Trade and Environment Nexus in Mexican Agriculture. 1996. draft.
- Bray, David B. "Of Land Tenure, Forests, and Water: The Impact of the Reforms to Article 27 on the Mexican Environment." In Reforming Mexico's Agrarian Reform, ed. Laura Randall. 343. New York: M.E. Sharpe, Inc., 1996.
- Castilleja, Guillermo and Martin Goebel. "Can Mexican Forests Survive NAFTA?" Journal of Forestry 93 (10 October 1995): 60.
- Commission for Environmental Cooperation (CEC) Registry of Submissions. <http://www.cec.org/english/citizen/registry.html>.
- \_\_\_\_\_. "Summary of Environmental Law in Mexico (draft)", <http://www.cec.org/english/database/law/Mexico/15/1504.htm>.
- de Janvry, Alain, Elisabeth Sadoulet, Benjamin Davis, and Gustavo Gordillo de Anda. "Ejido Sector Reforms: From Land Reform To Rural Development." In Reforming Mexico's Agrarian Reform, ed. Laura Randall. 343. New York: M.E. Sharpe, Inc., 1996.
- DeWalt, B. R., and Rees, M. W. (1994). The End of Agrarian Reform in Mexico: Past Lessons, Future Prospects (Transformation of Rural Mexico Series No. 3). Center for U.S.-Mexican Studies, University of California, San Diego.
- Esty, Dan. NAFTA Effects: A Survey of Recent Attempts to Model the Environmental Effects of Trade: An Overview and Selected Sources. Commission for Environmental Cooperation, 1996. Environment and Trade Series 1.
- Grindle, Merilee S. State and Countryside: Development Policy and Agrarian Politics in Latin America. Baltimore: Johns Hopkins Press, 1986.

Lynch, Loretta Marie. "Agricultural Trade and Environmental Concerns: Three Essays Exploring Pest Control, Regulations, and Environmental Issues." PhD. University of California, Berkeley, 1996.

Margulis, S. (1992). Back-of-the-Envelope Estimates of Environmental Damage Costs in Mexico ( Policy Research Working Papers No. WPS 824). World Bank.

Munasinghe, Mohan, Wilfrido Cruz, and Jeremy Warford. "Are Economywide Policies Good for the Environment?" Finance and Development 30 (3 1993): 40-43.

Myhre, David. "Appropriate Agricultural Credit: A Missing Piece of Agrarian Reform in Mexico." In Reforming Mexico's Agrarian Reform, ed. Laura Randall. 343. New York: M.E. Sharpe, Inc., 1996.

NAFTA's Broken Promises: The Border Betrayed - Executive Summary. Public Citizen, [http://www.citizen.org/orgs/public\\_citizen/pctrade/borderexec.html](http://www.citizen.org/orgs/public_citizen/pctrade/borderexec.html).

NAFTA Economic Monitoring Task Force. NAFTA: Year Two and Beyond. Economic Research Service, 1996. NAFTA - 5.

Nelson, Gerald C. and Daniel Hellerstein. "Do Roads Cause Deforestation? Using Satellite Images in Econometric Analysis of Land Use." American Journal of Agricultural Economics, forthcoming.

Reed, D. (Ed.). (1992). Structural Adjustment and the Environment. London: Earthscan Publication Ltd.

Wexler, Matthew B. and David B. Bray. "Reforming Forests: From Community Forests to Corporate Forestry in Mexico." In Reforming Mexico's Agrarian Reform, ed. Laura Randall. 343. New York: M.E. Sharpe, Inc., 1996.

Whiteford, Scott and Francisco Bernal A. "Campesinos, Water, and the State: Different Views of La Transferencia." In Reforming Mexico's Agrarian Reform, ed. Laura Randall. 343. New York: M.E. Sharpe, Inc., 1996.