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The Greenest Trade Agreement Ever?

MEASURING THE ENVIRONMENTAL IMPACTS OF AGRICULTURAL LIBERALIZATION

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IN 1993, THE CLINTON ADMINISTRATION hailed the North American Free Trade Agreement (NAFTA) as the "greenest" trade agreement ever completed.[1] Despite this promise, NAFTA and its parallel environmental accord remain the source of intense debate. A decade after the agreement entered into force, disagreements continue around the basic facts of NAFTA, as well as whether it has kept its pledge of promoting sustainable development, preserving the environment, and ensuring that environmental laws guarantee high levels of environmental protection.[2] In 2001, Public Citizen dismissed the environmental provisions of NAFTA as "meaningless."[3]

Measuring the environmental impact of trade remains complex, despite advances that have been made in assessment methods, underlying data, and empirical evidence. Environmental quality is subject to change, often unexpectedly and from a myriad of sources. Since free trade affects the economy indirectly and often weakly, the impact of trade on environmental quality also tends to be indirect and weak.[4]

Despite methodological challenges in identifying causal links, studies confirm that trade exerts two types of pressure on the environment. First, trade can affect environmental quality through scale impacts. There is rarely, if ever, a linear relationship between economic scale and environmental impacts, since the former tends to be offset by more efficient technologies, compositional changes (for instance, from agriculture to the manufacturing or services sector) or the harmonization of standards among trading partners, all associated with trade liberalization.[5] Second, trade rules can influence environmental policy directly, by affecting policy on food safety, the environment, conservation, and other areas of domestic concern. This second area has remained at the center of the trade and environment agenda for more than a decade. Despite predictions that the trading system would become overwhelmed with trade-environment cases, this has not occurred either under NAFTA or the World Trade Organization (WTO). A limited number of precedent-setting environmentally related disputes have occurred involving NAFTA Chapter 11 investor-state disputes.

Environmental reviews of trade liberalization continue to focus on the economic sectors that are most affected by NAFTA liberalization schedules, and which are environmentally sensitive. These sectors include pollution-intensive industrial and manufacturing sectors, as well as resource-based sectors, such as cement, and renewable resource sectors, such as fisheries and forestry.

During the past decade, somewhat less attention has focused on the environmental impacts of

NAFTA's agricultural provisions. Understanding agricultural liberalization (or the failure to liberalize farm trade) is important from an environmental perspective. No other sector exhibits such a close, symbiotic relationship as that of terrestrial farming and the environment.

I examine some changes in U.S.-Mexican farm trade, and focuses on three principal environmental issues: (a) the rise in the overapplication of nitrogen, phosphorus, and other agrochemical inputs; (b) the depletion of groundwater due to increased crop irrigation; and (c) the vicious circle of poverty and income divergence, subsistence farming, and high rates of deforestation and changes in land use (this third issue being the leading cause of habitat degradation and loss of biological diversity in southern Mexico).

To assess the effects that NAFTA has had on nitrogen pollution, water scarcity, and biological diversity losses, I examine changes in Mexico-U.S. trade in three crop groupings—wheat, maize, and fresh vegetables and fruit. Trade in each group has been strongly affected by NAFTA-specific liberalization disciplines (in contrast to what has occurred under the WTO Agreement on Agriculture), shifting demand patterns as a function of rising income in some urban areas, fluctuations in drought conditions and severity, and other factors.

Wheat. U.S. exports of wheat to Mexico have increased by 182 percent since 1992. This export increase has in turn contributed to an 80 percent compositional shift in the production of wheat varieties within Mexico's breadbasket region, from bread wheat to durum wheat. The production of both varieties in the semiarid regions of northern Mexico is heavily reliant on irrigation drawn primarily from groundwater. Over the past decade, groundwater tables have declined by approximately 50 percent in the breadbasket area of the Yaqui Valley. Durum wheat requires greater total amounts of fertilizer inputs in semiarid regions, compared to bread wheat. Although Mexico's aggregate consumption of fertilizers has remained roughly constant since NAFTA, following the end of state-supported fertilizer subsidies, fertilizer use has become more concentrated in larger-scale, export-oriented farms. During the past decade, increases in nitrogen and other chemical loading from agrochemicals have been recorded in groundwater in Sonora and other commercial farming regions.

Nitrogen runoff is the largest pollution source in Mexico, the United States, and Canada. It is also the leading cause of eutrophication and algae blooms affecting Mexico's rivers and lakes, the Sea of Cortez, and the Gulf of Mexico. The ecological effects of nitrogen pollution tend to be greater in Mexico than in the United States, given Mexico's warmer waters—which can accelerate algae blooms—and much larger concentration of freshwater and coastal marine biological diversity. The compositional change from bread wheat to durum wheat can be explained largely by structural changes consisting of vertical integration of durum wheat with upstream food processing. Durum wheat is used for the production of pasta. Since enactment of NAFTA, pasta processing has been among the largest recipients of foreign direct investment (FDI) inflows in Mexico, aside from the manufacturing and services sector. Mexico's exports of all pasta types to the United States have increased by approximately 50 percent since NAFTA took effect.

Maize/Corn. U.S. maize exports to Mexico have increased by 240 percent since 1992. Increased U.S. imports may pose an environmental risk to traditional Mexican maize varieties. Laboratory tests conducted in 2002 confirmed that genetically modified corn has been introgressed in Oaxaca and elsewhere. This introduction has occurred despite the import ban imposed by Mexico on biotechnology corn seed in 1998. Given that Mexico is a center of origin for more than forty maize varieties, the risk posed by the genetic contamination of traditional varieties in biologically rich areas, such as Oaxaca, may be of global concern. A large proportion of U.S. maize imports to Mexico are used as

grain-feed inputs for that country's quickly expanding livestock sector, as well as in the syrup industry. While most livestock production in Mexico meets rising domestic demand (reflecting a change in diet in middle-income households from grains to meat and processed foods), exports to the United States of calves and cattle have also increased since NAFTA. NAFTA has accelerated structural changes in the maize sector by way of deepening vertical integration with livestock operations and the sugar industry. Environmental pressures associated with the concentration of large-scale confined-animal feedlot operations in Mexico appear to resemble environmental pressures recorded in the United States and Canada, albeit at a lower level. Finally, a marginal increase in maize production in the United States to serve the Mexican market is the cause of increased environmental pressures in the United States. Increased maize exports from the United States result in an increase of 77,000 tons of nitrogen, phosphorus, and potassium-based loadings to U.S. waterways, with emissions concentrated in the already heavily polluted Mississippi River Delta.

Fresh Vegetables and Fruit. Since enactment of NAFTA, Mexican exports of all fresh vegetables have increased by 80 percent, and exports of fresh fruit have increased by 90 percent. Structural changes in Mexico's horticulture sector have been especially pronounced since NAFTA took effect, although structural changes commenced with liberalization reforms introduced in Mexico in the 1980s. On average, export-intensive horticulture farms are larger, rely on standardized capital inputs such as fertilizers and pesticides, specialize in single crops, and have a far greater propensity toward irrigation, compared to smaller farms serving the domestic market in Mexico. Field data suggest that larger, export-oriented farms are less sensitive to smaller, *ejido* farm holdings, and use greater amounts of groundwater irrigation per yield, compared to smaller farms. Mexico is one of the most water-stressed countries in the Western Hemisphere, and its expansion of exports of fresh fruits and vegetables is the main anthropogenic cause of this water stress. The export of horticulture products to the United States represents the transfer of millions of gallons of freshwater equivalent each year. For example, the export of tomatoes from Mexico to the United States accounts for the equivalent transfer of approximately 162 million gallons of freshwater equivalent to the United States each year since 1993.

Based on these limited examples, I draw the following three conclusions. First, there is little evidence that the environmental safeguards in NAFTA have directly improved environmental quality in the farm sector. To date, none of the environmental safeguards inserted in NAFTA or its environmental side accord—the North American Agreement for Environmental Cooperation—have been used in any disputes involving agricultural liberalization. At the same time, the accelerated NAFTA liberalization schedule adopted by Mexico to phase out tariff-rate quotas for maize has opened the maize market too quickly to imports and related price and employment shocks. During this turbulent transitional period, this market has increased ecological risk in Mexico, as well as environmental damage in the United States. Finally, the absence in NAFTA of disciplines that can constrain farm subsidies for maize, wheat, and other crops has led to an increase in total subsidy payments in the United States, with the amended 2002 Farm Act, as well as increased subsidy payments in Mexico. Increased farm subsidy payments have increased pricing and market failures, resulting in the overproduction of some crops, as well as the excessive application of fertilizers and other capital inputs, which further magnifies environmental degradation. In addition, the pattern of subsidy payments appears to favor large farms over smaller ones, thereby contributing to the expansion of subsistence farming in marginalized areas in the southern regions of Mexico.

My second conclusion is that NAFTA has accelerated the structural shift toward large-scale, commercially viable, export-oriented farms. Clearly, this restructuring began well before

NAFTA, with the introduction of liberalization reforms in the late 1980s in Mexico. However, recalling the argument of Jeffrey Sachs and Andrew Warner that the opening of the economy through trade liberalization is the "*sine qua non* of the overall reform process," it is reasonable to assume that NAFTA has both accelerated and significantly deepened structural changes in Mexico.[6] In addition, the distribution of subsidy payments has accelerated structural changes in the grains and horticulture sector so as to favor large-scale, export-oriented, vertically and horizontally integrated farms. The structural shift appears to have increased the concentrations of nitrogen and phosphorus, water-polluting agrochemicals used as inputs in larger-scale farms. Export-oriented farms also appear to use greater amounts of irrigated water inputs per yield, compared to producers of similar products destined for domestic markets. Since farming is the largest consumer of freshwater by a very wide margin, this structural shift has magnified water scarcity in Mexico.

My third conclusion is that commercially oriented farms have not delivered environmental benefits associated with intensive farming. Those environmental benefits typically derive from land-saving effects associated with an increase in production efficiency. The main reason for this failure to deliver environmental benefits appears to be the structure and extent of poverty and the pattern of income divergence in southern Mexico. While commercial cultivation of some crops has expanded, downward price premiums on staples, such as maize, has increased poverty in this region. The average deforestation rate in the biologically rich southern regions of Mexico has exceeded 630,000 hectares per year since 1993. The leading cause of deforestation in Mexico remains poverty, with slash-and-burn clearing and tree felling by poor households in need of fuel remaining the leading causes of forest clearing. In addition, small-scale, rain-fed maize production has increased by 18 percent in marginalized areas, as poor farmers respond to falling prices.

The environmental costs of deforestation and changes in land use in Mexico are staggering. That country is one of the planet's leading centers of "megadiversity," home to 10 percent of all known species, of which 30 to 50 percent are endemic. Mexico has the world's second-highest number of reptile species, and ranks fourth for amphibians and fifth for mammalian diversity in the world.[7] However, the geography of this biological diversity coincides exactly with Mexico's geography of extreme poverty.

Trade theory scarcely hides the unhappy fact that there are winners and losers from trade liberalization. However, people—especially indigenous peoples in the poorest regions of southern Mexico—maintain an enduring allegiance to their ancestral homes, community ties, and traditional knowledge, which date back 6,000 years. Given that these ties reach deeper than economically rational decision making, millions of poor farmers who are clearly losers on the ledgers of free trade remain committed to their lands, despite structural changes in the farm sector that increasingly lock them out of commercially viable markets.

The most important environmental challenge arising from NAFTA is to build a bridge between aspects of the dual farm economy in Mexico—a divide characterized by larger, commercial farms in the northern and central regions and subsistence, *ejido*, and small-family holdings. Although commercial farming has not taken hold in Mexico to the extent it has in the United States or other industrialized countries, this stylized distinction between large and small is nevertheless useful in showing the trajectory of structural changes in the agricultural sector. Although standard economic theory says that unprofitable farm production should relocate, there is nowhere for millions of poor farmers to go, since the contraction in Mexico's agriculture has not been accompanied by an expansion in other sectors.

Economic shocks experienced during the adjustment period of liberalization often appear to be

intractable. However, innovative solutions that re-engage public institutions and policy, that build partnerships with private agriculture and other sectors, and that are intent on nurturing the commercial viability of farms are needed for environmental reasons alone (aside from compelling social equity and poverty alleviation objectives), as a means to slow rates of deforestation and habitat loss, as well as protect Mexico's biological diversity. One solution can be protected areas. Real spending on nature reserves has increased significantly since 1993, to US$6.5 billion a year. However, competition among indigenous groups, communities, and illegal squatters in these reserves remains strong, while trust in collective solutions remains fragile at best. Moreover, protected areas have never been a lasting solution to broader, in situ biological diversity protection.

A second solution involves nurturing new commercial opportunities in the poorest regions to generate higher revenue returns to farmers, relative to subsistence farming underway in marginal areas. Viable commercial alternatives that can close part of the poverty gap do exist in specific market niches, those that center on ecofriendly products or anticipate new revenue streams from emerging environmental markets. Examples include ecotourism, carbon sequestration, and organic and sustainable farming. As in other markets, information failures and structural rigidities continue to constrain Mexico's full participation in these quickly growing global markets, in part because of liberalization and mergers in the country's banking system. With the dramatic consolidation of the banking sector, private credit channels assume that only large-scale farms are creditworthy, an assumption that leads to the disappearance of almost all small-scale farm credit. For example, the leading reason why small-scale farmers abandon their operations and rent their lands to commercial interests in the Sonora region is credit scarcity. Solutions to redress this working capital bottleneck now include the creation of the Sustainable Coffee Fund, which is supported by the North American Commission for Environmental Cooperation (NACEC), Banamex, the largest commercial bank in Mexico, the government of Mexico, and other partners. These efforts should be expanded, with the active participation of large-scale, U.S.-based produce buyers, whereby a proportion of seasonal contract farming arrangements are channeled toward funding sustainable agricultural markets.

NAFTA and the Environment: A Difficult Relationship

The economic gains from NAFTA are typically measured by the kind of statistics cited in chapter 1. These economic gains are traditionally calculated by estimating gross savings, which is gross national product (GNP) minus public and private consumption. However, in the last decade, efforts have been made to measure, quantify, and internalize environmental costs in standard economic measurements, and some progress has been made in "greening" national income accounts. This process includes calculating relatively explicit costs, such as resource extraction, as well as making depletion calculations from the loss of forestry resources, pollution damages, and other factors. Some methods of green accounting rely on standardized proxies of environmental damage values, such as the US$20 per metric ton of carbon emitted that is used to calculate the marginal global damage of climate change. Other factors, such as soil degradation, the loss of tropical forests, or the loss of fisheries stocks, are considerable, but extremely difficult to quantify except through site-specific field studies to impute environmental values, based on people's willingness to pay for their conservation.[8]

In 2002, the government of Mexico—one of the world's leaders in environmental valuation and green accounting—estimated that the total value of environmental damages exceeded US$36 billion per annum since 1990.[9] If these environmental damages were included in GNP and gross domestic product (GDP) estimates, then Mexico would have run an ecological deficit the equivalent of US$9 billion per

year.[10] Clearly, NAFTA has not been responsible for most, or even a significant portion, of these total environmental damages. However, they underline the fact that economic growth generates considerable pressures on the environment through scale effects.

A decade ago, surprisingly little attention was focused on the scale effects of trade-led economic growth. Since NAFTA is the first trade accord to include explicit environmental provisions and safeguards, it remains the subject of debate among pro- and anti-globalization activists generally. This debate still hinges on two regulatory, as opposed to scale, effects:[11]

- The free-trade accord would begin a "race-to-the bottom," as states would lower environmental standards to attract investment.

- If environmental standards remained intact despite the competitive pressures of free trade, then companies would move production to "pollution havens," places where regulations did not exist or did not matter.

A decade, later, the environmental record of NAFTA remains mixed. Neither the great benefits claimed by proponents nor the overwhelming damages predicted by critics have come to pass. In the manufacturing sector, which due to its pollution intensity has been subject to closet scrutiny, NAFTA has contributed directly to an increase of between 1 and 2 percent in annual gross emissions of carbon monoxide and sulfur dioxide, due to changes in the petroleum, base metals, and transportation equipment sectors.[12] NAFTA has also contributed directly to air pollution spikes in the Canadian-U.S. and U.S.-Mexican border regions, as 80 percent of total NAFTA trade is transported via truck-transport passing through increasingly congested border points.[13] NAFTA Chapter 6 energy provisions have contributed to an increase in carbon dioxide emissions arising from increased U.S.-Canadian trade in electricity, as well as increased Mexican exports of electricity to the United States.[14]

In other cases—notably in the production of cement, steel, and nonferrous metal industries—the environmental performance of Mexican companies since the enactment of NAFTA has been superior to that of their U.S.-based counterparts.[15] This improvement is partly explained by increased FDI inflows that accelerate the turnover of capital stocks in these sectors, leading to the adoption of more efficient and less polluting process technologies. The improvement is also explained by increased environmental awareness within Mexico—as in other countries—since the late 1980s. Regulations introduced in the early 1990s strengthened Mexico's environmental statues and institutional capabilities. U.S.-Mexican cooperative action on a number of fronts—notably in tackling environmental pressures along the border—has reduced some, but hardly all, environmental pressures. Trilateral cooperation through NACEC has supported the international benchmarking of some environmental norms, such as the harmonization of toxic release data and the development of criteria for air pollutants among the three North American countries. The harmonization of environmental data is an important step toward comparing the environmental performance of Canada, Mexico, and the United States.[16] Environmental awareness has catalyzed other more systemic reforms within Mexico, notably in improving access to information and codifying public participation.[17]

The good news that NAFTA has not created pollution havens hardly means that NAFTA is environmentally benign. In addition to the two anti-NAFTA assertions—the race to the bottom and the pollution haven—a third assertion from the NAFTA debates is that trade is somehow self-cleansing. That is, as incomes rise as a result of free trade, the rate of environmental degradation decelerates and gradually improves.[18] Unfortunately, real-world evidence shows that only a few pollution indexes decline with economic growth, and mostly at the subregional level. Most important, pollution reductions take place as a result of tightly enforced environmental regulations combined with the replacement of

capital stock by more resource-conserving technologies.[19] While some benefits do occur, evidence suggests that other environmental quality indexes rise almost continuously with income growth, notably greenhouse gas emissions.

The most debated relationship between environmental laws and NAFTA rules is in the area of investment. Under NAFTA, private investors are given new opportunities to seek compensation for regulatory action taken by NAFTA parties that is tantamount to expropriation. By 2003, ten of NAFTA's Chapter 11 cases involving allegations of expropriation associated with changes in domestic environmental regulations had taken place. One dispute compelled the Canadian government to modify its import ban on methylcyclopentadienyl manganese tricarbonyl (MMT), and pay damages to a U.S. firm totaling US$13 million. Three other cases have resulted in paid damages totaling US$10 million. In response to these cases, in July 2001 the NAFTA parties negotiated a clarification of their intentions regarding investment rules, designed to minimize national governments' exposure to expropriation cases.[20]

Notwithstanding the NAFTA Chapter 11 cases, the greatest environmental pressure associated with NAFTA is transmitted through the scale effects of economic growth, to which trade liberalization contributes. In the manufacturing sector, environmental regulations—as strong as they were on paper with the passage of NAFTA—did not keep pace with rates of economic growth. Mexico's manufacturing sector has grown by 4 percent per annum since enactment of NAFTA, but real spending on pollution monitoring and on-site inspections has fallen by 45 percent over the same period. Overall, air pollution has increased 10 percent per year in the manufacturing sector of Mexico since NAFTA took effect.[21]

Clearly, NAFTA has been solely responsible for neither increased pollution emissions nor the weakening of environmental enforcement. All North American countries have experienced some weakening of domestic environmental regulations that has coincided with NAFTA, such as the recent delay of some U.S. Clean Air Act–mandated schedules for emission reductions with the introduction of the Bush administration's Clear Skies initiative. However, a case cannot be made that the Clear Skies initiative is linked to NAFTA.

Measuring Environmental Effects and Mexico's Farm Sector

Changes in the manufacturing sector provide one important insight into trade-environment relationships. However, for many countries, the most significant interaction between trade liberalization and environmental quality is transmitted within the agricultural sector. This is especially true for developing countries, whose primary exports are agricultural products. There are three main reasons why it is vital to examine the environmental impacts of agricultural liberalization in general, and its impact on Mexico's farm sector in particular.

Pollution. Farming is the leading source of pollution in Canada, Mexico, and the United States. The excessive application of nitrogen—an important element in fertilizers—contributes to high soil salinity and the presence of air-polluting ground-level ozone, disrupts forest processes, acidifies lakes and rivers, and degrades coastal waters and ecosystems through algae blooms and groundwater pollution.[22] Since 1993, Mexico's total consumption of nitrogenous fertilizers has remained roughly constant (see Figure 1). However, with the withdrawal of state subsidy support for fertilizers in the mid-1990s, the pattern of fertilizer consumption has shifted away from small-scale, undercapitalized farms and increasingly toward larger-scale operations. This shift in fertilizer purchases has magnified a pattern of concentration of fertilizer inputs in those areas in which more intensive farming is

underway. In addition, imports of nitrogenous fertilizers into Mexico have increased sharply since enactment of NAFTA (see Figure 2).

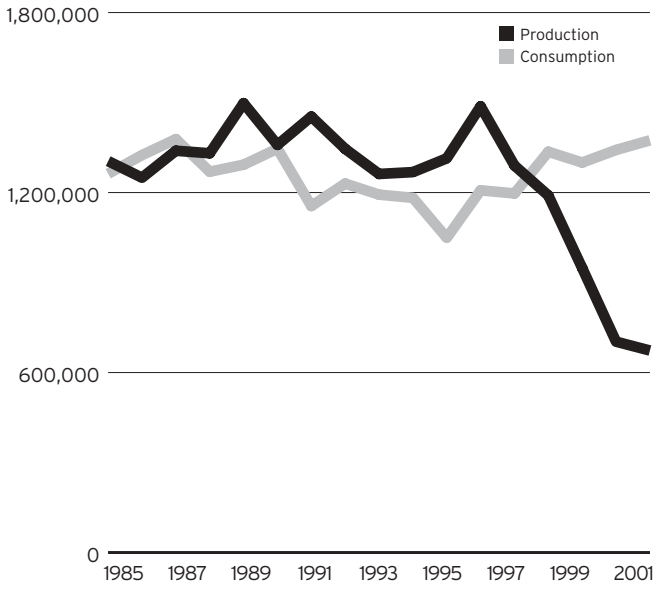
A similar trend of increased pesticide imports into Mexico from the United States also occurred during the first decade of NAFTA (see Figure 3).

As a nonpoint pollution source, nitrogen pollution is significantly more difficult to monitor and regulate, compared to point-source industrial pollutants.[23] (It is uncertain whether the 45 percent decrease in spending for environmental monitoring and enforcement affected, one way or the other, scale effects of rising pollution levels in the agricultural sector. That is, even if on-site inspections were unaffected by budget rollbacks—which seems extremely unlikely—inspectors lack the capability to monitor and regulate most nonpoint pollution sources, with the exception of the livestock sector and perhaps the cotton production sector.)

Freshwater. Agriculture is by a wide margin the largest consumer of freshwater (see Figure 4) in Mexico. More than 80 percent of Mexico's annual water draws are consumed in farming.[24] Water scarcity is not only the most urgent environmental and developmental problem facing Mexico, it has increasingly become the subject of political and diplomatic tension between the United States and Mexico. In 2002, Presidents George W. Bush and Vicente Fox Quesada jointly promised to resolve Mexico's 450 billion gallon water deficit with the United States, under provisions of a 1944 treaty setting out shared water management quotas between the two countries for the Rio Grande.

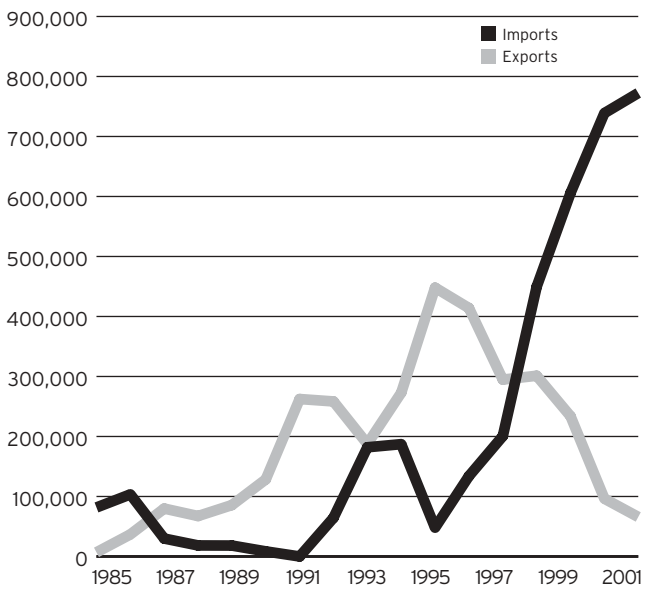
Biological Diversity. Agriculture is the leading cause of changes in land use, such as the deforestation that brings with it habitat destruction. In turn, these changes in land use are the leading cause of the destruction of ecologically rich habitats and biological and agricultural diversity in Mexico. The loss of biological diversity is of global environmental

Figure 1. Mexico's Consumption of Nitrogenous Fertilizers
MEGATONS



Source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT online statistical service, www.fao.org (FAO, Rome, 1999).

Figure 2. Mexico's Imports and Exports of Nitrogenous Fertilizers
MEGATONS



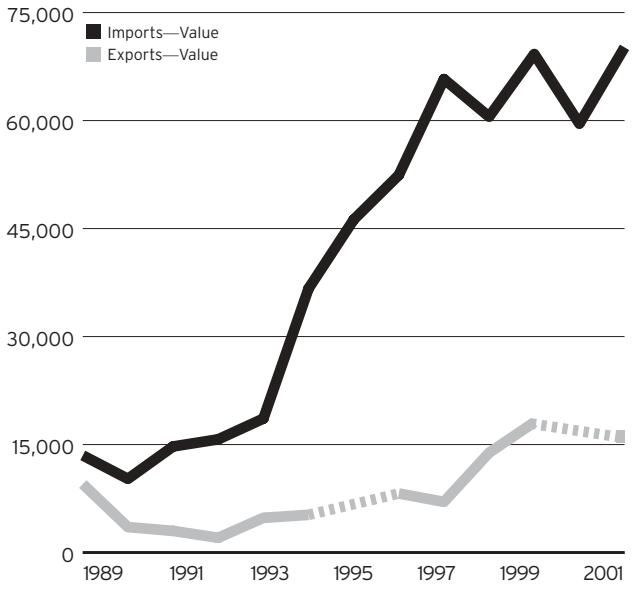
Source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT online statistical service, www.fao.org (FAO, Rome, 1999).

significance, since Mexico houses some of the richest and most important endowments of biological diversity on the planet, concentrated in its southern tropical forests (as well as in its coral reefs). Mexico is home to 10 percent of all known species, of which 30 to 50 percent are endemic. Mexico has the world's second-highest number of reptile species, and ranks fourth for amphibians and fifth for mammalian diversity in the world. Mexico also has one of the highest deforestation rates in the Western Hemisphere. Since 1993, about 7.8 million hectares of forest have disappeared. While rates have decelerated in recent years, more than 631,000 hectares of forests have been cleared on average every year since 1990. Poverty remains the leading cause of deforestation, and thus, the extinction of flora and fauna.[25] Specifically, the expansion of subsistence farm areas into marginal lands to increase yields to compensate for price declines in staple crops such as maize remains the leading cause of forest clearing, followed by the felling of trees for poor-income household fuel use. Therefore, there is a strong link between poverty and biodiversity loss in southern Mexico. The issues I address below are the effect that NAFTA has had on this poverty-environmental degradation nexus, as well as the risk of genetic erosion affecting traditional maize varieties.

Environmental Impacts of NAFTA-Induced Trade in Agriculture

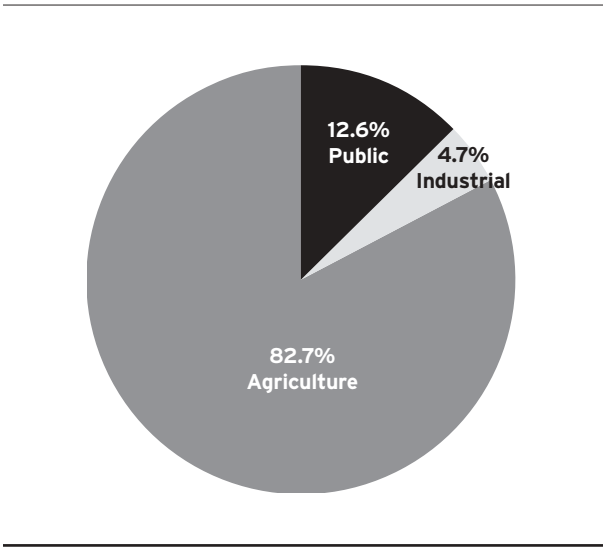
Given the robust relationship between agricultural land use and environmental quality, I begin my discussion of the contribution NAFTA has made to changing environmental conditions by examining the total changes in U.S.-Mexican agricultural trade volumes. Table 1[26] summarizes some of the major changes in Mexico's domestic farm production and in net agricultural imports, which overwhelmingly originate in the United States.

Figure 3. U.S. Insecticide Trade with Mexico
U.S. DOLLARS



Source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT online statistical service, www.fao.org (FAO, Rome, 1999).
Note: Dotted lines indicate missing data from 1995 and 2000.

Figure 4. Distribution of Mexican Water Use



Source: Compendio Básico del Agua en México, 2002, Plan Nacional de Desarrollo (PND), Comisión Nacional del Agua (CAN), Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT).

The value and volume of North American farm trade has grown more rapidly than has North America's trade with the rest of the world. Exports from Mexico to the United States have more than doubled in value, from US$2.5 billion to US$5.1 billion, since enactment of NAFTA, while U.S. exports to Mexico have almost quadrupled, to US$6.8 billion. Clearly, NAFTA has successfully strengthened agricultural ties throughout North America, particularly between the United States and Mexico.

Working from the data on these overall changes, I examine the proportion of U.S.-Mexican trade that has solely, or significantly, been affected by NAFTA (as opposed to the liberalizing effects of WTO agreements, as well as important nontrade variables such as climatic fluctuations and drought, market proximity and shrinking transport costs, and changes in consumer food preferences).[27] On an aggregate basis, the impact of NAFTA-specific liberalization on U.S.-Mexican agricultural trade has been minor; for decades, the U.S. and Mexican agricultural economies have been moving toward deeper integration. However, for a typical basket of agricultural goods, NAFTA has had a significant impact on U.S.-Mexican agricultural trade.

U.S. exports to Mexico that fall into this category include maize/corn, rice, sorghum, cotton, processed potatoes, fresh apples, and pears. Mexican exports to the United States that have been strongly affected by NAFTA-only schedules include wheat, cattle and calves, sugar, fresh tomatoes, and cantaloupe.[28] Since it is impossible to weigh the environmental impacts of production, consumption, and export changes for all commodities involved in trade, I focus only on some environmental consequences associated with wheat, maize, and fresh fruit and vegetables, all of which have been significantly affected by NAFTA.[29]

MAIZE

Mexico is a center of origin for *Zea mays,* the ancestral precursor of modern corn. Approximately 3 million farmers in Mexico, mostly from small-scale farms, are involved in maize production. Indirectly, some 18 million people depend on maize for their livelihood. Traditional maize is not only a staple food of Mexican diet; it also provides a symbolic lifeline connecting traditional and indigenous cultures dating back approximately 6,000 years—since the time that maize was first cultivated—with the modern Mexico of today.[30]

Table 1. Changes in Mexico's Domestic Farm Production and Agricultural Imports
THOUSANDS OF MEGATONS

	Average Production 1990–93	Average Production 1999–2002	Average Net Imports 1990–93	Average Net Imports 1999–2002
Wheat	3,799	3,277	917	2,592
Maize	15,965	18,891	1,691	5,751
Barley	418	709	171	145
Sorghum	4,556	5,888	3,547	5,005
Rice	257	308	332	660
Soybeans	273	308	1,747	4,205
Sugar	3,577	4,798	393	-337
Beef	1,202	1,422	-21	191
Pork	803	1,061	47	169
Poultry	908	1,854	70	249
Tomatoes	1,173	2,186	-361	-691

Source: Organization for Economic Cooperation and Development, *Agricultural Policies in OECD Countries: Monitoring and Evaluation* (Paris: OECD, 2003), available at www.oecd.org.

Although estimates remain difficult to obtain, approximately 35–40 percent of U.S. corn is derived from genetically modified (GM) varieties. A debate over the benefits and costs of GM crops has been underway ever since biotechnology was approved for some commercial crops in the United States, Canada, and elsewhere in the mid-1990s.[31] One response to the potential risk of GM crops, was the introduction of a Mexican ban on the import of genetically modified corn seeds in 1998.[32] Despite this ban, in 2001 *Nature* magazine published a peer-reviewed article demonstrating that GM corn had been found growing in Mexican fields.[33] This sparked scientific concern, as well as a highly visible public debate, about the risks of genetic contamination as well as mutation.[34] Subsequent independent laboratory tests conducted by the Mexican government have confirmed that contamination by biotechnology corn has occurred in Oaxaca—a global center of megadiversity—and elsewhere in Mexico. Neither the pathways of that contamination, nor the ecological implications that could arise from it, are clearly understood at this time.

A scientific consensus exists that the risks to human health from GM foods are low or nonexistent.[35] In the United States, biotechnology foods are embedded throughout processed foods that contain soybeans and corn. In the area of food safety, the potential risks that biotechnology crops pose to the environment differ from those normally raised in regard to human health, and include the possible impact of GM crops on soil ecology, farmland diversity, and even gene flow change.[36] A recent study by the European Environment Agency has found that maize poses a medium to high risk of pollen-mediated gene transfers from crop to crop, concluding that "evidence suggests that GM maize plants would cross-pollinate non-GM maize plants up to and beyond the recommended isolation distance of 200 meters."[37]

In addition to recorded cases of GM maize pollination, similar cases in which gene stacking involving genetically modified canola have been recorded since 1991 in the Canadian prairies. Affected canola crops in western Canada appear to be more resistant to herbicides than conventional (non-biotechnology) crops.

In early 2004, NACEC will finalize an independent analysis that examines the environmental and conservation risks that science associates with the possible contamination by biotechnology crops of traditional crop varieties such as Mexican maize. Given the implications of this case for the Biosafety Protocol of the UN Convention on Biological Diversity,[38] as well as for the application of the precautionary principle to international trade, the NACEC report will be the most important and controversial ever issued in the ten-year history of that NAFTA-related organization.

The increase in U.S. corn imports also risks weakening in situ conservation involving some or all of the forty races of maize that are grown in Mexico, with some varieties dating their origin back 6,000 years. While there has been an absolute contraction in maize production in Mexico since the enactment of NAFTA, led by a free fall in commercially harvested crops, production of rain-fed maize has remained stable. To date, there is little evidence that NAFTA has undermined in situ conservation of maize. However, the price difference of approximately 27 percent between U.S. corn and Mexican varieties suggests that over time the price wedge may result in U.S. imports crowding out rain-fed varieties. This substitution will eventually present small-scale farmers with three choices: exit farming altogether; diversify the composition of crop output; or concentrate on fledgling but potentially high-growth market niches that award a price premium for traditional, organic, and sustainable produce such as traditional maize. Each presents formidable obstacles to small-scale farmers. As noted in chapter 1, there are few economic and employment alternatives for millions of farmers in Mexico. At the same time, the quality of soil in marginal lands makes crop switching very unlikely. Finally, even if market niches for sustainable produce expand dramatically, this will not alleviate

all pressures on in situ conservation. Therefore, the long-term erosion of the knowledge base on which traditional maize growing is based is one of the greatest conservation threats directly posed by NAFTA.

In addition to the explanations for the persistence of rain-fed maize identified by Sandra Polaski in chapter 1, a further reason why rain-fed varieties have remained stable or increased slightly may be traced to the large proportion of corn imports that are used as grain feed for Mexico's quickly expanding livestock sector.[39] Structural changes associated with the horizontal integration of maize as an input to confined animal feedlot operations and slaughterhouses have been dramatic in Mexico.[40] These structural changes result in a series of interlocking environmental pressures that very-large-scale feedlot and slaughter operations pose to environmental regulators.

Environmental pressures from intensive livestock operations include large volumes of nitrogen, phosphorus, hydrogen sulfide gases, and atrazine pesticide, leading to soils that are overenriched with nutrients while posing threats to local watersheds with runoff that can cause algae blooms, loss of habitat, changes in aquatic biological diversity, and depletion of dissolved oxygen.[41] These wastes can also contain pathogens, antibiotics, and hormones.

Recently, episodes of neurological disorders affecting individuals living close to these industrial farms have also been reported.[42] Although data from Mexico delineating different sources of nitrogen pollution are far from complete, the data that exist point to some convergence in environmental pressures arising from livestock operations in Mexico with those that exist in the United States and Canada. This is hardly surprising, given the strong consolidation of the North American livestock sector fueled by mergers and acquisitions during the 1990s. Today, four firms control 81 percent of the U.S. and Canadian cattle and beef market, and a similar pattern of market consolidation is underway in Mexico, although at a slower pace. In the same way that turnkey industrial plant investments incorporate uniform capital stock and management policies, livestock operations in any one location of North America are increasingly similar to operations elsewhere.

The main focus of environmental attention has been on potential risks within Mexico because of U.S. corn imports. At the same time, environmental pressures have increased within the United States itself, because of the production increase to serve the Mexican market. The 240 percent rise in U.S. corn exports has resulted in a doubling of the proportion of total U.S. production that is destined for Mexico, from 1 to 2.1 percent of total domestic production. I assume that the entire 1 percent production increase is attributed to NAFTA, and conclude that expanded production of corn in the United States destined for Mexico generates an additional 77,000 tons of nitrogen-, phosphorus-, and potassium-based pollution per year.[43] This increase in pollution is concentrated in the Mississippi River Delta, already the most polluted region of the United States because of nitrogen runoff and related ecological stress. In addition, increased corn production is exacerbating water scarcity in those states that have high irrigation intensities for corn production, notably Nebraska, Kansas, and Texas.[44]

WHEAT

Since enactment of NAFTA, U.S. exports of wheat to Mexico have increased by 182 percent, resulting in a 1 percent increase in U.S. wheat production. In general, economic models anticipate that trade liberalization will bring about a shift in the location of grain production, with production contracting in industrialized countries and increasing in developing ones.[45] However, for wheat and corn production, the opposite pattern took place: U.S. exports to Mexico increased, while commercial production in Mexico contracted.

In contrast to maize output, Mexico's output of wheat has not altered significantly since enactment

of NAFTA. Instead, wheat production in the Yaqui Valley—the birthplace of the green revolution for wheat and the breadbasket of Mexico today—remains the region's leading agricultural activity (accounting for roughly 85 percent of total planted crop area).[46] However, the composition of wheat production in the region has changed dramatically since 1993. Then, bread wheat made up the bulk of total wheat output. By 2002, bread wheat output in the region had declined from roughly 80 percent of total production to 15 to 20 percent. In bread wheat's place, durum wheat—which constituted a small percentage of total production in 1993—now accounts for more than 80 percent of the total wheat output in the Yaqui Valley.

The change from bread wheat to durum wheat has not altered the region's severe water scarcity. Through a combination of drought and surface conditions in the area, the levels of groundwater—the main source of irrigation for wheat production—have declined by half since 1991.[47] At the same time, the production shift from bread to durum has directly led to an increase in nitrogen pollution in the region. In arid and semiarid regions such as the Yaqui Valley, durum wheat requires as much as 20 percent more fertilizer inputs within irrigated systems than other wheat crops. This compositional production shift has directly led to increased fertilizer inputs, and increased nitrogen pollution and nitrogen runoff associated with eutrophication in nearby rivers and lakes. Estimates suggest that the application of nitrogen per hectare in the Yaqui Valley exceeds 250 kilograms, making this region among the heaviest users of fertilizers on a per hectare basis in the world.

In Sonora, Sinaloa, and other states where intensive farming occurs, ecological pressures from nitrogen pollution have risen dramatically. The main source of nitrogen pollution in the Sea of Cortez originates from commercial agricultural production in Sonora. Nitrogen pollution is increasing in the Tacana River Basin and the Rio Lerma. Eutrophication has significantly lowered the inflow time of the Rio Lerma to Lake Chapala—the largest freshwater body in Mexico and a center of rich biological diversity. Uncontrolled blooms of water weeds have increased since the late 1980s, and now cover more than 10 percent of Lake Chapala's surface area.[48] Although nitrogen pollution in Mexico is less than in the Mississippi River Delta or Chesapeake Bay, its effect is more ecologically destructive in the warmer waters of Mexico. For example, eutrophication in the Sea of Cortez is a main source of stress on coral reefs—which have a higher concentration of biological diversity than most tropical forests—and coastal plankton.[49]

Durum wheat is used to produce dry pasta and pasta products. The food processing sector has been among the largest recipients of FDI inflows to Mexico since NAFTA investment liberalization disciplines were set out in Chapter 11. FDI inflows have more than doubled in Mexico's food processing sector, to more than US$5.3 billion, concentrating on a narrow set of value-added food processing activities, led by pasta (and followed by confectionery products, for which corn syrup is increasingly used as an input).[50] As Mexico's domestic production capacity for pasta foods has increased, so too have its exports to the United States. Since NAFTA, Mexican exports of all kinds of pasta have grown relatively constantly, from 20 million kilograms in 1995 to more than 31 million kilograms in 2001 (see Figure 5).

FRESH VEGETABLES AND FRUIT

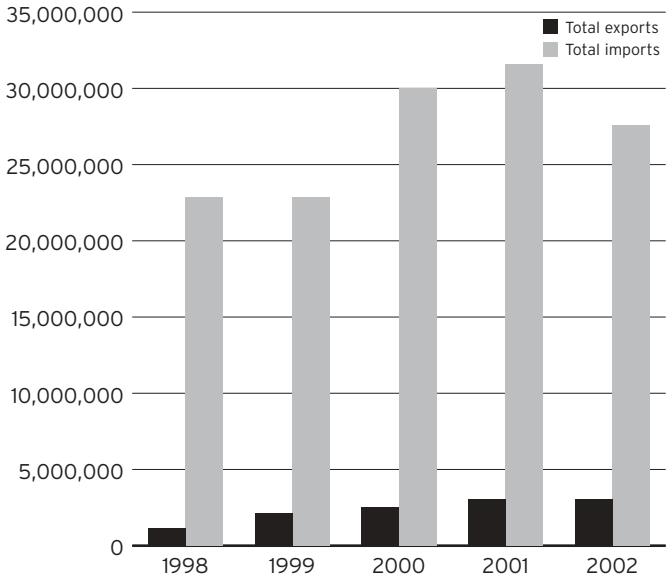
Horticulture has seen its export earnings roughly triple since NAFTA took effect, up to US$3.5 billion in 2000. Since enactment, the volume of fresh vegetable exports has increased by 80 percent, and of fresh fruit, by 90 percent. This production and export growth has resulted in an increase in the total area of cropland dedicated to vegetables and fruit.[51]

The most pronounced structural change in Mexico's agricultural sector due to NAFTA has occurred in the fresh vegetables and fruit sector.[52] The most important aspect of this structural change is the

expansion in the average farm size among export-led producers in the grains and horticultural sector, and a decline in the number of individual farms engaged in export markets. In the north, northwest, and central plateau areas, a smaller number of larger farms are owned either by wealthy families or by commercial interests.[53] Typically, these farms have strong links with external markets, through contract farming (see page 78) and ready access to domestic and external credit sources. Larger farms specialize in a limited number of monoculture commercial crops. This specialization entails replacing on-farm inputs such as organic pest control and local fodder and composting with pesticides, commercial animal feeds, and fertilizers. Specialization also entails higher rates of irrigation per hectare, and the replacement of traditional seed varieties with hybrid, purchased seeds (as well as biotechnology seeds for cotton crops).[54]

By contrast, in the southern and southeastern regions of Mexico, there are a larger number of smaller farms, with an average size between 2 and 5 hectares. Farms are either owned by single families or compose part of *ejido* (community) holdings. Smaller farms produce heterogeneous crops for on-farm consumption, barter as well as some limited farm-gate exchange, tend to use few inputs such as pesticides or fertilizers, and rely little on irrigation. High obstacles are one reason for this low level of capital intensity that small farmers face in getting access to all credit sources in Mexico. As a consequence of this credit squeeze, up to 70 percent of *ejido* farmers in some regions (for example, Sonora) have decided to abandon farming altogether. (This figure is probably much higher than in other regions, since less land appears to have been transferred out of common property than originally feared. For those who remain on the farm, barely 18 percent of household income for *ejido* farms in some regions is generated through on-farm crop cultivation and animal husbandry.)

Figure 5. Total U.S. Pasta Trade with Mexico
KILOGRAMS



Source: U.S. Census Bureau, Foreign Trade Division (www.census.gov)

As noted in chapter 1, income divergence within Mexico has increased over the past decade, measured by any number of indicators. Nowhere is this divergence more dramatic than in the farm sector. From an environmental perspective, poverty in Mexico is concentrated in regions—particularly in Oaxaca and Chiapas—that house some of the world's richest abundance of biological diversity.

The production of commercial fruits and vegetables in the northern region leads to nitrogen pollution similar to that generated in the maize and wheat sectors. However, the most significant environmental stress that arises from this sector is water scarcity. On average, one-third of Mexico's total cropland is irrigated, one of the highest concentrations of irrigated farmland in the world.[55] There has been a slight increase in the total amount of irrigated land in Mexico since NAFTA, as the most dramatic rise in irrigation occurred during the previous decade (see Figure 6).

Research shows that irrigated groundwater for water-intensive crops such as tomatoes, pecans, and

alfalfa is applied on average more intensively for export crops than for crops bound for the domestic market. Evidence from Sonora demonstrates that export crops in the fresh fruit and vegetable category consume 20 to 30 percent more groundwater irrigation than crops intended for domestic consumption.

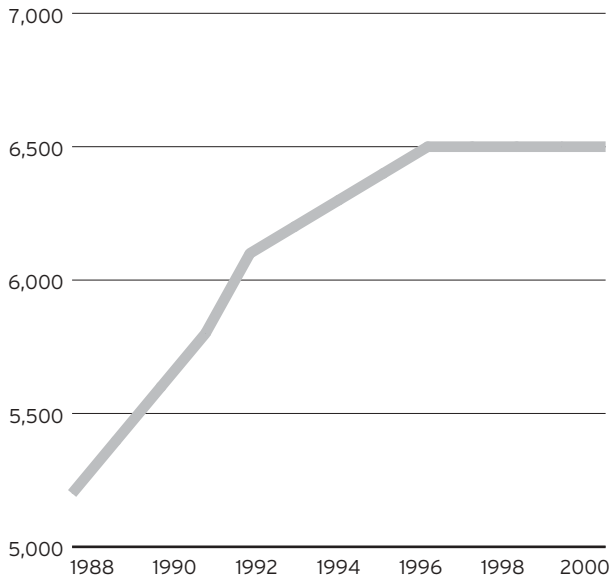
Larger farms use significantly greater amounts of irrigated water per yield than single-family or *ejido* farms. A number of factors explain this correlation between farm size and irrigation intensity, beginning with the degree of technological specialization that generally can be associated with larger farms, as well as the water abundance of the southern regions. Nevertheless, larger farms use irrigation more intensely in Mexico, suggesting a convergence between intensity of irrigation and farm size like that observed in the United States. (In the United States, larger farms have a tendency to use irrigation systems more than smaller farms, and a tendency to use irrigation system more efficiently and accurately. Irrigated farms in the United States also generate twice the income of their rain-fed counterparts.)[56] However, the inverse correlation of farm size and irrigation intensity is more dramatic in Mexico, where a full 80 percent of *ejido* and single-family farms in some regions do not use irrigation of any kind.[57] The most plausible explanation for this absence of irrigation intensity can be traced directly to the virtual disappearance of rural credit in the past decade. As noted, 70 percent of *ejido* farmers in some regions have abandoned farming altogether, and rented their right of access to groundwater wells and irrigation systems to larger private or corporate farm interests.

This pattern of larger farms using greater amounts of irrigated groundwater for export crops is exacerbated by the structure of *ejido* ownership, which constrains the amount of groundwater extraction so as to ensure an equitable sharing of resources among eight to twelve owners. By contrast, larger farms are not constrained by any equitable sharing considerations, which suggests that they are less sensitive to water scarcity and water stress signals than are *ejidos.*[58] In addition, the pattern of water irrigation subsidy payments is slanted—as subsidy payments generally are—in favor of larger, commercial farms. As noted below, subsidy payments generally further cloud scarcity signals, and lead to resource stress and environmental pressures.

As a result primarily of water consumption from the farm sector, water scarcity has become so acute a problem in Mexico that bulk water transfers—prohibited in Canada because of their negative environmental impacts—have compensated for regional water deficits. In total, agricultural irrigation is responsible for approximately 65 percent of total groundwater draws in Mexico. Of the 459 aquifers in the country, more than 80 face high rates of depletion. The greatest concentration of depleted groundwater sources is in the northern agricultural regions and in the Lerma-Balsas Basin.[59]

Irrigation inputs for export crops have been linked to the U.S.-Mexican dispute over water flows and quotas of the Rio Grande. The United States and

Figure 6. Irrigated Land in Mexico
THOUSANDS OF HECTARES

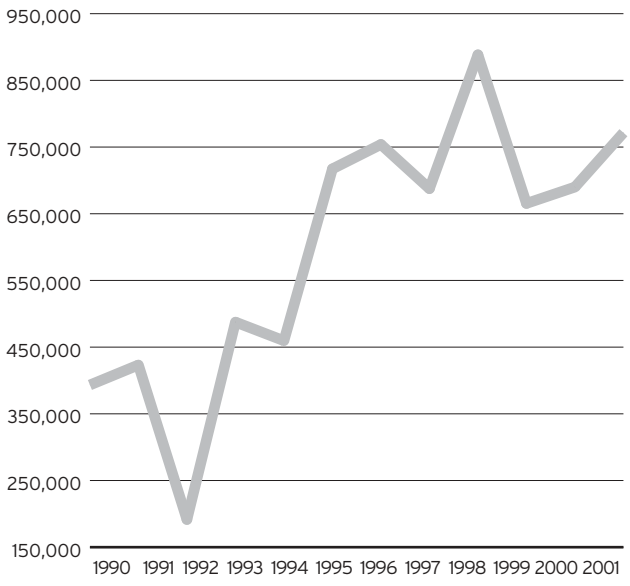


Source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT online statistical service, www.fao.org (FAO, Rome, 1999).

Mexico have established water-sharing quotas for that river, under a 1944 treaty administered by the International Boundary and Water Commission. Since 1992, Mexico has run a deficit with the United States that now exceeds 450 billion gallons of water. Mexican authorities blame severe drought conditions for their decision to withhold northward water flows from Mexico into Texas. In turn, farmers in Texas have faced acute water shortages, leading to a 15 percent decline in crop output in some regions. Some of these farmers, and state and other officials in the United States, allege that some of the 450 billion gallon deficit has been diverted to water-intensive agricultural production in Mexico, with exports destined for the United States.[60] (In early September 2003, the two countries announced a timetable for Mexico to begin paying down the water deficit.)

When one considers this water deficit with the United States, and mounting water scarcity within the export centers of northern Mexico, it is also worth noting that Mexico's horticultural exports are the equivalent of transferring millions of gallons of freshwater each year to the United States. While it is impossible to calculate this net transfer in water equivalents for all agricultural trade, I will consider here the example of a single crop, tomatoes. Figure 7 illustrates the expansion of tomato exports from Mexico to the United States since 1990. As noted, exports of tomatoes increased by 90 percent since 1993, with trade growth strongly affected by NAFTA. Water makes up approximately 90 percent of tomatoes by weight. A proxy estimate of the water transfers from Mexico to the United States alone through tomato exports is roughly 162 million gallons of freshwater per year since 1993.[61]

Figure 7. Tomato Exports from Mexico to the United States
METRIC TONS



Source: Food and Agriculture Organization of the United Nations (FAO), FAOSTAT online statistical service, www.fao.org (FAO, Rome, 1999).

LAND-SAVING BENEFITS AND INTENSIVE FARMING

NAFTA is neither the sole cause, nor, in most cases, the primary cause of growing environmental pressures associated with Mexico's agricultural sector. Mexico's changing agricultural patterns date back to the 1980s, when the government encouraged export-oriented agricultural production by facilitating large-scale farming through land law reforms. That said, NAFTA liberalization in maize, wheat, and fruits and vegetables has accelerated and deepened this trend toward export-oriented, chemical-intensive production.[62] The key question is whether this shift toward intensive farming has, on a net basis, delivered environmental benefits, as well as the obvious environmental costs associated with pollution and water stress.

One tenet of the green revolution is that, despite localized increases in pollution, environmental benefits can accrue based on large-scale, intensive farming. These benefits arise from land-saving and land-offsetting effects of intensive farm production.[63] With the increased reliance on capital inputs such as fertilizers, pesticides, and bioengineered seeds, production efficiency increases on average, either by reducing the total amount of land needed for comparable yields or by increasing the yield per hectare of existing land use. This increase in produc-

tion efficiency reduces pressure on farms to convert additional lands, including marginal lands or forests, to meet the rising demand for food. A stylized image of this hypothesis is that of a seesaw: The more that specialization and intensive farming goes up in one region, the more that land-use pressures associated with extensive farming recede elsewhere.

Although the extent of potential benefits is specific to the region under consideration, Pedro Sanchez and others have argued that, as a rule of thumb, for every hectare of land that is converted into intensive farming, between 5 and 10 hectares of tropical forests will be conserved elsewhere.[64] In the United States, for example, intensive farming has been estimated to "save" 90 million hectares of forests that otherwise would have been cleared for farming.

In areas with smaller, low-productivity, unprofitable farms, the lack of access to working capital means that environmental problems associated with fertilizers and pesticides are almost entirely absent. However, more serious from an environmental perspective is the strong link between impoverished southern rural areas and changes in land use, deforestation, and habitat destruction and fragmentation.[65] Rural poverty is the leading cause of environmental degradation in the Lacandon jungle—among the richest habitats on the planet. Poor farmers continue to clear tropical forests to plant crops. However, since the nutrient composition of tropical forests is concentrated in the biomass of trees above, and not in the soil found below, farmers usually get only one crop per season before soils are exhausted of nutrients, and they are forced to move elsewhere to clear additional forests for more cropland or grazing areas.

However, evidence from Mexico and elsewhere now shows that land-saving benefits that could arise from intensive farming are neither automatic nor of the magnitude observed in industrialized countries such as the United States. One reason for this failure to deliver automatic land-saving benefits may be that the returns of the green revolution began to bottom out some years ago.[66] For example, soil degradation arising from high levels of salinity has reduced crop output in many commercial farming regions.

Diminishing returns of intensification may partially explain why the expansion of commercial farms in the northern and central regions has not resulted in forest-saving benefits in the southern regions. However, the most plausible explanation for the failure of land-saving benefits to occur is the structural bifurcation of Mexico's farm economy. Productivity gains occurring in the northern and central regions have little or no impact on subsistence farming and associated land clearing in the poorest, southern regions of Mexico. The simplest explanation is that the seesaw does not work, because it has become unhinged in the middle. NAFTA accelerated and deepened the structural divide between large-scale, vertically integrated, export-oriented farms and small-scale, subsistence farms to the extent that no market signals are transmitted between the two. (Even in well-functioning markets, increased economic opportunities can also lead to an expansion of crop areas.)

In well-functioning markets, as the total amount of available land shrinks, farmers will increase capital inputs as the principal means of increasing yields. The single most important catalyst of more intensive farming is land scarcity. In Mexico, one potential cause of land scarcity—particularly in the southern regions—is the nature reserves throughout Mexico, with a total land coverage of priority biosphere reserves. In the past, these reserves were little more than "paper parks"—lines on a map with little or no budget for enforcement. However, with the support of the U.S. Agency for International Development, the Global Environment Facility, Pro Natura, and other groups, the newly established Mexican Fund for Conservation of Nature has a total funding base for all protected areas of US$6.5 billion per year.[67]

Despite increased spending, some of which can be attributed to more general environmental cooperation

that NAFTA has supported, nature reserves in Mexico remain chronically underfunded and underenforced, which leaves them vulnerable to illegal land use, animal husbandry, and competition among indigenous groups and others.[68] Since, by definition, setting aside protected areas creates losers in the immediate regions in which reserves are created, neighboring residents have a high propensity to cheat, by way of illegal logging, land clearing, and corruption and nonenforcement among park officials.[69] Therefore, potential land-scarcity signals that could originate from reserves, which would in well-functioning markets lead to land savings through intensive farming, are probably not affecting land-use decisions in Mexico.

Other, nontrade factors clearly contribute to the deterioration of pricing and other signals linking commercial and small-scale farms. Four are noted below.

Farm Subsidies. As in other countries, the pattern of subsidy payments in Mexico supports large-scale farms over small ones.[70] Although farm-sector lobbyists argue that farm subsidies generally are needed to support farm income, payments are not being channeled into the most impoverished areas of southern Mexico. At the aggregate level, only one-quarter of total farm subsidies support farm income. By contrast, 75 percent are directed to offset capital costs of various production inputs—such as fertilizers, herbicides, machinery, and farm fuels, as well as to change the market value of farmland. Since extensive farms by definition do not specialize in capital inputs, most farm subsidies are directed toward larger, intensive farming operations. For example, the structure of water irrigation subsidies disproportionately favors large-scale farms over small ones, while the pattern of payments under the PROCAMPO and ASERCA programs also appears to benefit large-scale farmers.[71] Moreover, PROCAMPO payments are intended to bolster land saving by supporting liberalized, intensive farming. However, they have had the opposite impact in the Yucatan Peninsula, where rates of deforestation have accelerated by as much as 34 percent, largely because PROCAMPO increased land values, which had the effect of accelerating land clearing rather than intensification on existing lands (see Figure 8).[72]

The environmental impacts of production subsidies are well documented,[73] and include overproduction and excessive application of agrochemicals, irrigation, and other production inputs. Although NAFTA was hailed as an environmental agreement, its failure to include strict disciplines that constrain farm subsidy payments has rendered various environmental safeguards (with the possible exception of food safety standards) powerless to minimize environmentally damaging subsidy payments. NAFTA has therefore been no more successful than the WTO in constraining subsidy payments in North America, most recently seen in the United States in the increase in total farm payments under the 2002 Farm Act. This increase in subsidy payments in the United States is closely related to an increase in some subsidy payments in Mexico.[74]

Contract Farming. The bias of subsidy payments toward commercial farms is reinforced by the increased reliance on contract farming as a primary avenue of Mexican agricultural exports to the United States, especially for fresh vegetables and fruit. Contract farming is hardly unique to Mexico, nor can it be attributed to NAFTA.[75] The main environmental effect of contract farming is the imposition of production criteria by suppliers on growers. Typically, these criteria cover not only price, quantity, and quality, but some production specifications, including the mandated use of fertilizers, pesticides, and other technical specifications that only larger farms can afford.[76] Field research in Guanajuato shows that contract buyers exclusively engage in business with large-scale growers. This is done to reduce transaction costs. Average farm size in Guanajuato for farms under contract is 31 hectares, more than ten times the average size of an *ejido*.[77] For tomato farms in the region, the average farm size is 1,000 to 2,000 hectares. Supply contracts explicitly set out requirements for pesticides,

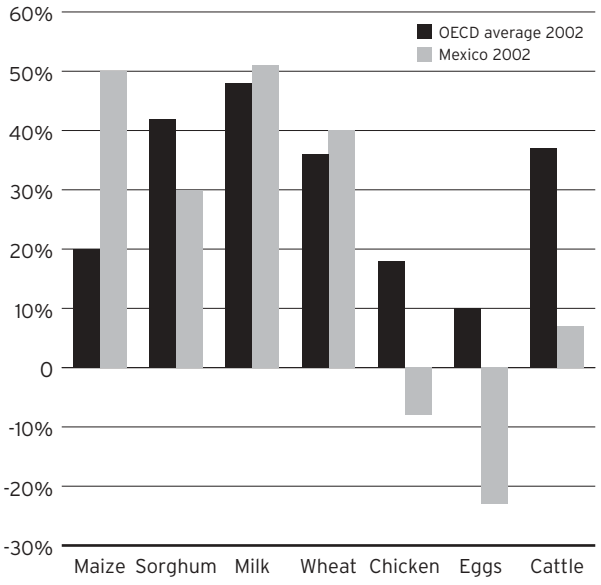
fertilizer, and other production inputs (for example, plastic sheet covers for tomato farms).

Narrowly speaking, NAFTA has had no bearing on how private commercial contracts between exporters and buyers are negotiated and implemented. However, the structure and pattern of export growth in the horticultural sector has been strongly affected by NAFTA. This expansion has led to structural changes favoring larger farms, which in turn are strongly favored by large-scale buyers entering into contract farm arrangements. The structure of these arrangements suggests at the very least a tension among NAFTA liberalization of some barriers (notably tariffs and tariff-rate quotas), the diminished role of spot markets, and their replacement with consolidated markets serving large-scale, oligopolistic buyers.

Disappearing Rural Credit. The pattern of larger, export-oriented farms supported by subsidies and commercially engaged through contract farming is magnified by the dramatic retreat of all commercial credit from smaller farming operations. With the consolidation of Mexico's banking sector during the 1990s[78] (see Figure 9), credit policy and risk management procedures have become more homogeneous, and have explicitly turned away from the financing of smaller-scale businesses of all kinds. Banks in Mexico have complained to the World Bank about the lack of "creditworthy" clients, and credit is increasingly directed to larger corporations and government agencies.[79]

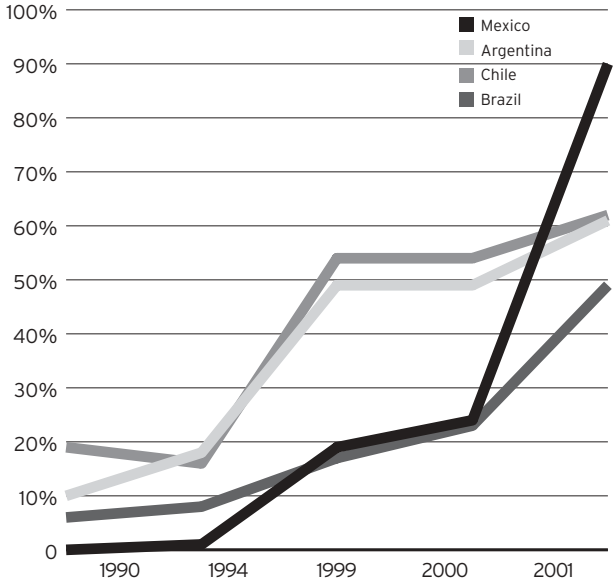
As commercial credit evaporated for all small enterprises, Banrural, the public development agency for rural credit, was until 2003 the sole credit source for small farms in Mexico. However, immediately upon its creation, Banrural shrank the number of outstanding loans by half.[80] Even with this rationalization of credit policy, the performance of Banrural has been miserable by any standard. In 2002, 40 percent of its portfolio was nonperforming. The collapse and dismantling of public agencies and credit institutions coincided with the dramatic consolidation of private-sector capital that was clearly unwilling to fill the

Figure 8. Producer Subsidy Equivalent: Mexico



Source: Organization for Economic Cooperation and Development, PSE/CSE database, 2002 (www.oecd.org).

Figure 9. Foreign Share of Banking Assets



Source: Economic Commission for Latin America and the Caribbean (ECLAC), "Foreign Investment in Latin America and the Caribbean," 2002, www.eclac.org.

void left by public microfinance policy in full retreat. (In May 2003, the World Bank announced a US$505 million loan to liquidate Banrural and begin again, with a new rural credit agency devoted to low- and middle-income farmers.)[81]

The scarcity of farm credit has profoundly affected land-use decisions. As noted above, the leading reason why single-family farms and *ejido* farmers in some commercial regions rent their lands to private commercial interests is the absence of rural credit.[82] Evidence also suggests that whatever farm credit which is extended tends to favor intensive farming. That is, farms that receive credit usually defer decisions about fertilizer dose amounts to the recommendations of credit authorities, who recommend an "excessive" use of fertilizers.[83] In addition, financing extended through contract farming appears more plentiful, and much cheaper. U.S.-denominated farm loans to support exports in the Yaqui Valley have interest rates of 13 to 18 percent, while peso-denominated farm credit—if it is available—is between 25 and 30 percent. (Black market rates can exceed these levels per month.)[84]

The Cost of the Dual Economy on Biological Diversity

It is impossible to quantify the total value of Mexico's tropical and other forests, environmental services derived from wetlands and other habitats, and biological diversity. One of the few global estimates, by Constanza et al. (1997), suggests that the total annual value of the world's ecosystem functions is approximately US$36 trillion.[85] Although this study is useful in suggesting the order of magnitude of environmental values, it has come under criticism on various fronts, largely on methodological grounds.

At the same time, it is clear that most environmental values—but particularly those values associated with biological diversity—remain uncounted, undervalued, and external to market prices. In one small step to redress this externalization problem, numerous environmental valuation field studies have been conducted in Mexico. The combined economic values suggested by these studies are impossible to aggregate, since they rely on different methodologies and baselines, generally consist of decentralized research (unlike the climate change agenda, which is conducted under the UN Intergovernmental Panel on Climate Change), and tend to concentrate on very small areas, such as lagoons or specific parts of tropical forests or coral reefs.[86]

Despite the difficulties in valuing Mexico's forests and biological diversity, we know with certainty that those values are substantial, conservatively running into billions of dollars for direct values such as ecotourism. Other values are more difficult to quantify. For instance, the value of a single wild-grass perennial grass variety related to maize is estimated to be US$6.8 billion per year.[87] Potential revenues from carbon sequestration are in the range of US$31.5 million to US$126 million for Mexico's forestry sector alone, depending on the price per ton of carbon equivalent in world markets.[88] The value of possible carbon sinks from low-till farming, as well as grasslands and commercial and other forestation projects outside tropical regions, is much higher. Rather than attempt to quantify the full value of Mexico's biological diversity that has been put at risk because of the cycle of rural poverty and changes in land use from slash-and-burn clearing, one could take the more practical approach of identifying practical and achievable policy options as a means of gauging the transfer of benefits associated with conservation of Mexico's biological diversity. Some of these benefit transfers are noted below. They include ecotourism and shade-grown and organic produce, both of which gain their market and revenue value precisely because of the worth consumers place on biological diversity.

Lessons and Recommendations

Structural changes under way in Mexico's agricultural sector did not begin with NAFTA, nor has NAFTA been the sole cause of these changes. However, structural changes influenced largely by NAFTA in the horticultural and grains sectors reinforce and magnify changes that are further influenced by other, non-NAFTA forces, such as the liberalization of the financial services sector and consolidation of export farms through subsidy payments and contract farming. Moreover, NAFTA has prompted action among rural communities to reopen the trade agreement to take into account the vulnerability of communities to trade, including the adoption of the National Rural Accord by communities in the spring of 2002.[89]

NAFTA has reduced some pricing distortions, by lowering or eliminating tariffs and tariff rate quotas. At the same time, NAFTA has failed to constrain the use of farm subsidies, which have deepened pricing and market failures and accelerated environmental degradation through overcapacity. Structural changes linked with trade growth have introduced new forms of market failure, in particular the replacement of spot markets for fruit and vegetables with concentrated markets patronized by oligopoly buyers exerting high levels of buying power through contract farming. A similar oligopoly in the private banking sector helps explain the virtual disappearance of private credit for small and mid-sized enterprises, in particular small-scale farms.

Those worst affected by structural changes associated with trade liberalization and trade growth are Mexico's poor farmers. Alan Winters observes that the poor in developing countries are disproportionately affected by trade liberalization: Adjustment periods for the poor are long and very costly. Winters concludes that the industrialized countries can offer little guidance to developing countries in addressing the problems of the poor who have been adversely affected by free trade.[90]

The most important challenge from an environmental perspective alone is to address the plight of small-scale farms in Mexico, by identifying commercially viable revenue sources that are equal to or greater than the subsistence income derived from subsistence farming on marginal lands.[91] Given the strong pull that southern farmers, indigenous peoples, and communities in the region feel toward their land, providing grants for employment training and relocation—even if financing were available—would not break the circle of poverty and environmental degradation.

One source of hope may originate in markets that are taking shape because of environmental considerations. The global market for environmental goods and services remains fragile and incoherent. However, evidence suggests that small-scale, undercapitalized farms can gain a comparative advantage in several environmental market niches such as organic goods, precisely because they cannot afford fertilizers, herbicides, pesticides, and GM seedlings. Consumers in Europe, Japan, the United States, and Canada are showing an increased preference for produce that is *not* grown with pesticides or other input. For example, the global market for organic foods alone exceeds roughly US$20 billion a year, and remains the fastest-growing segment of the food industry, recording sales volume increases of 20 to 30 percent per year. The North American market for certified, shade-grown, sustainable coffee is US$152 million on the retail side, while the global market value (including noncertified coffees that are marketed as sustainable, bird-friendly, organic, or under other labels), is US$565 million per year in retail sales.[92]

Mexico is the world leader in shade-grown organic coffee; similar opportunities exist for other crops, including traditional maize varieties, cocoa, spices, honey, and palm. The environmental benefits of these kinds of products are well documented in some cases. For example, coffee grown under tree canopies typically has 90 percent more on-site bird life, compared to sun-grown coffee raised on plan-

tations that clear forests.[93] Similar markets for ecotourism and eventually carbon sequestration are likely to channel new revenues into southern Mexico.[94]

Although these markets are small, they require capital to overcome market failures, as well as to differentiate their products in the market through labeling, certification, and the use of geographic indicators, and to arrange transportation and overcome intermediary market barriers. One of NACEC's outstanding contributions is to create a special fund to support small-scale, community, or cooperative-based shade-grown coffee certification and export promotion in Oaxaca, Chiapas, and other regions of southern Mexico. Among the supporters of the fund are Banamex and the government of Mexico. This fund is building one bridge between the two farm economies of Mexico. Working with the reconfigured coffee subsidy payments can make it possible that Mexico's poverty circle can be broken thanks to new markets that value environmental attributes.

This chapter has described a series of issues that, taken together, continue to affect agriculture in Mexico. These include trade liberalization prompted by NAFTA, the liberalization and consolidation of the financial services sector, the concentration of vertically integrated sectors within Mexico's farm economy, the effect of agricultural subsidies, and the increasingly important pull that contract farming is exerting on the production decisions of farmers. NAFTA is not the cause of these issues' emergence, but it remains the focal point of most liberalization reforms undertaken in Mexico since 1993. From an environmental perspective, these liberalization issues are linked together by a chain of poverty affecting poor farmers, indigenous peoples, and communities in southern Mexico. Initiatives that support sustainable niche markets will not break this chain of poverty and environmental degradation. However, evidence from market analysis and sales shows signs of hope that new income sources from green markets can bolster environmental protection by opening new revenue sources to the poor.

Neighboring countries in Central and South America have different histories, economic and environmental endowments, social traditions, and levels of economic reform. At the same time, many of these countries share a common environmental heritage, from the Meso-American biological diversity corridor to rich ecosystems of coastal marine and tropical forestry areas in South America. There is no one-size-fits-all formula for how to anticipate the environmental effects of trade liberalization. However, we do know that the poverty-environment nexus in the agricultural sector will be affected in similar ways, as in Mexico during the 1990s. Anticipatory policies include ensuring that working capital is available to small farms when it is most urgently needed during the transitional period of liberalization; that liberalization schedules do not open vulnerable markets too quickly; that discrete environmental markets are supported; and that environmental monitoring and data are focused from the outset, to track and offset scale impacts of free trade.

NOTES

1 In September 1993, President Bill Clinton declared that NAFTA would "lead to improvements in the environment and increased investment on the Mexican side of the border in environmental cleanup." Carol Browner, the administrator of the U.S. Environmental Protection Agency, went further, stating that NAFTA was the "the most environmentally sensitive trade agreement in history."

2 NAFTA Preamble, CEC Article 3, BECC/NADBank, Article 1, Section 1.

3 Public Citizen, *NAFTA Chapter 11 Investor-State Cases: Bankrupting Democracy,* September 2001, www.citizen.org.

4 Evidence showing a robust, linear relationship between trade liberalization and economic growth is weak and uneven, with that relationship generally inferred by measuring the relative openness of an economy. A strong empirical case exists showing that open economies grow quicker than do closed ones. Measures of economic openness vary, but include indicators of trade liberalization such as tariff and subsidy levels. See, for instance, Robert J. Barro, *Determinants of Economic Growth: A Cross-Country Empirical Study* (Cambridge, Mass.: MIT Press, 1999); and Michael Ferrantino, *The Dynamic Effects of Trade Liberalization: An Empirical Analysis* (Washington, D.C.: U.S. International Trade Commission, 1997).

5 The literature on environmental review methodologies is extensive. See, for example, Dale Andrew, ed., *Assessing the Environmental Effects of Trade Liberalization Agreements: Methodologies* (Paris: Organization for Economic Cooperation and Development, 1999); and Sarah Richardson, ed., *Assessing the Environmental Effects of the North American Free Trade Agreement: An Analytical Framework (Phase II) and Issues Studies* (Montreal, Canada: North American Commission for Environmental Cooperation, 1999).

6 Jeffrey D. Sachs and Andrew Warner, "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity* (Washington, D.C.: Brookings Institution, 1995).

7 Estrategia nacional sobre biodiversidad de México (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]: 2000), www.conabio.gob.mx/institucion/conabio_espanol/doctos/catalogo.html.

8 See Kirk Hamilton and Michael Clemens, "Are We Saving Enough for the Future?" in *Expanding the Measure of Wealth* (Washington, D.C.: World Bank, 1997). See also Robert Repetto et al. *Wasting Assets: Natural Resources in the National Accounts* (Washington, D.C.: World Resources Institute, 1989).

9 In the Mexican study, measurement of environmental damages relied largely on pollution indicators, notably air pollution indicators such as carbon dioxide, sulfur dioxide, nitrogen oxides, ground-level ozone, and airborne dioxins, with damages focusing on indicators such as increased mortality and morbidity impacts associated with air pollution; increased cancer risk from long-term, low-dose exposure to toxic substances; increased gastrointestinal illnesses from polluted drinking water; and damages to human health or more direct cleanup costs from hazardous wastes.

10 Kevin Gallagher, *Economic Integration, Environment, and Development: Assessing the Mexican Experience,* forthcoming.

11 For a summary of NAFTA's environmental provisions, see Daniel Magraw, ed., *NAFTA and the Environment: Substance and Process* (Washington, D.C.: American Bar Association, 1995). For a discussion of the politics of environment in NAFTA, see John Audley, *Green Politics and Global Trade* (Washington, D.C.: Georgetown University Press, 1997).

12 Kenneth Reinert and David Roland-Holst, "The Industrial Pollution Impacts of NAFTA: Some Preliminary Results," in Scott Vaughan, ed., *The Environmental Effects of Free Trade* (Montreal, Canada: North American Commission for Environmental Cooperation, 2002).

13 Rachel Poynter and Sheila Holbrook-White, "NAFTA Transportation Corridors: Approaches to Assessing Environmental Impacts and Alternatives," in Scott Vaughan, ed., *The Environmental Effects of Free Trade* (Montreal, Canada: North American Commission for Environmental Cooperation, 2002).

14 North American Commission for Environmental Cooperation, *Challenges and Opportunities in North America's Evolving Electricity Market* (Montreal, Canada: North American Commission for Environmental Cooperation, 2002).

15 *Economic Integration, Environment, and Development* (see note 10). See also Marisa Jacott, Cyrus Reed, Amy Taylor, and Mark Winfield, "Energy Use in the Cement Industry in North America," paper presented at the Second Symposium on Assessing the Environmental Effects of Trade, North American Commission for Environmental Cooperation (Mexico City, Mexico, March 2003), available at www.cec.org.

16 See North American Commission for Environmental Cooperation, *Taking Stock* (Montreal, Canada: North American Commission for Environmental Cooperation, 2003). For an overview of the mandate and work of the commission, see Gary Hufbauer et al., *NAFTA and the Environment: Seven Years Later* (Washington, D.C.: Institute for International Economics, 1997); Carolyn Deere and Daniel Esty, eds., *Greening the Americas: NAFTA's Lessons for Hemispheric Trade* (Cambridge, Mass.: MIT Press, 2002); and Jan Gilbreath, *Environment and Development in Mexico* (Washington, D.C.: Center for Strategic and International Studies, 2003).

17 Among the first public meetings ever held between the federal government of Mexico and members of nongovernmental organizations took place in the early 1990s, when environmental issues related to the proposed construction of a wharf in Cozumel were discussed. Since then, public consultations have become a regular feature of government in Mexico, extending to a range of public issues. For an account of some of these public consultation practices, see Timothy Whitehouse, ed., *Public Access to Government-Held Environmental Information: Report on North American Law,* 2d ed. (Montreal, Canada: North American Commission for Environmental Cooperation, 2003).

18 In the midst of the NAFTA debate in 1992, two economists—Grossman and Krueger—demonstrated that some indexes of pollution increase at the early stages of economic development, but then begin to decrease after a certain level of income is reached. The income turning point changed with the particular pollutant, but was in the range of US$5,000–$8,000 per capita GDP. The theory, known as the Environmental Kuznets Curve, was adapted from the work of Simon Kuznets, for his work in showing the relationship between level and inequality of income. The Grossman-Krueger hypothesis has sparked a very lively debate in the literature. See, for example, D. Stern, "Progress on the Environmental Kuznets Curve?" E*nvironment and Development Economics,* vol. 3 (1998), pp. 173–96; Theodore Panayotou, "Demystifying the Environmental Kuznets Curve: Turning a Black Box into a Policy Tool," *Environment and Development Economics* (special issue: The Environmental Kuznets Curve), vol. 2, no. 4 (1997), pp. 465–84; and K. G. Maler, "Environment, Poverty, and Economic Growth," in B. Pleskovic and J. Stiglitz, eds., *Annual World Bank Conference on Development Economics* (Washington, D.C.: World Bank, 1997).

19 See Susmita Dasgupta, Hemamala Hettige, and David Wheeler, *What Improves Environmental Performance? Evidence from Mexican Industry* (Washington, D.C.: World Bank, 1997).

20 See Howard Mann, *Private Rights, Public Problems: A Guide to NAFTA's Controversial Chapter on Investor Rights* (Winnipeg, Canada: International Institute for Sustainable Development and World Wildlife Fund, 2001). After numerous attempts to reach settlement, on July 31, 2001, the governments of Mexico, Canada, and the United States issued a clarification regarding NAFTA's Chapter 11. The statement addresses three issues: First, it makes clear that Chapter 11 does not preclude the parties from providing public access to documents submitted to or issued by a dispute panel. Second, it attempts to limit the scope of the legal terms "minimum standard of treatment" and "full protection and security" by restating a principle in customary international law regarding minimum standard of treatment. Finally, it limits efforts by investors seeking damages under NAFTA only to infractions that may arise under Chapter 11 disciplines, not other elements of the agreement. The full text of this statement can be found at the U.S. Trade Representative's web site, www.ustr.gov/regions/whemisphere/nafta-chapter11.pdf.

21 *Economic Integration, Environment, and Development* (see note 10).

22 Charles Driscoll et al., "Nitrogen Pollution: Sources and Consequences in the U.S. Northeast," *Environment,* vol. 45, no. 7 (September 2003).

23 R. Ford Runge, "Positive Incentives for Pollution Control in North Carolina: A Policy Analysis," in D. Huisingh and V. Bailey, eds., *Making Pollution Prevention Pay* (New York: Pergamon Press, 1982).

24 Sistema Unificado de Informacion Básica del Agua (2003), *Agua en México,* Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT) and Comisión Nacional del Agua, Mexico City.

25 Food and Agriculture Organization of the United Nations, "Forestry Data" (Rome: Food and Agriculture Organization of the United Nations, 1999), available at FAOStat, www.fao.org.

26 Organization for Economic Cooperation and Development, *Agricultural Policies in OECD Countries: Monitoring and Evaluation* (Paris: Organization for Economic Cooperation and Development, 2003), available at www.oecd.org.

27 Mexico's food consumption has changed as GDP per capita has risen on average. Consumption is moving away from unprocessed bulk commodities and toward higher-value foods such as meat, fresh fruits, dairy products, and processed foods. At the same time, rates of malnutrition and hunger have also increased.

28 Steven Zahniser and John Link, eds., *Effects of NAFTA on Agriculture and the Rural Economy* (Washington, D.C.: U.S. Department of Agriculture, July 2002), available at http://ers.usda.gov/publications/wrs0201/.

29 There are more than 200 different agricultural products traded among the NAFTA countries, each with different environmental characteristics depending not only on the specific crop but on the climate, soil, water, and other factors affecting how that crop is cultivated (or in the case of aquaculture and livestock, produced). Unlike in the electric power generating sector, there are no standardized or uniform emissions factors for these agricultural goods, with the possible exception of cotton. Given important differences in the environmental characteristics of different crops, it is not feasible to extrapolate more general or net environmental impact stemming from NAFTA liberalization from the three examples discussed in this chapter. Even if these differences were not so pronounced among crops, environmental quality indicators are generally disaggregated, making it difficult to compare changes in pollution with changes in water scarcity or biological diversity.

30 Alejandro Nadal, "Maize in Mexico: Some Environmental Implications of NAFTA," in Sarah Richardson, ed., *Assessing the Environmental Effects of NAFTA: An Analytical Framework* (Montreal, Canada: North American Commission for Environmental Cooperation, 1999).

31 The debate over the risks to health and the environment from GM foods and crops is far from settled. For example, there is now a scientific consensus that the risk to human health from consuming the current range of GM foods is low or nonexistent. A recent scientific panel report of the government of the United Kingdom concluded that *"on balance...the risks to human health for GM crops currently on the market are very low. But depending on the crops developed GM food may present greater challenges in risk management in the future"* (UK Government Science Panel Report, July 2003), available at www.gmsciencedebate.org.uk.

32 Chantal Line Carpentier and Hans Herrman, *Maize and Biodiversity: The Effects of Transgenic Maize in Mexico: Issues Summary* (Montreal, Canada: North American Commission for Environmental Cooperation, 2002).

33 D. Quist and I. H. Chapala, "Transgenic DNA Integressed into Traditional Maize Landscapes in Oaxaca, Mexico," *Nature,* vol. 414 (2001), pp. 541–43.

34 After attacks led by the biotechnology industry and others, *Nature* retracted the article in mid-2002, which in turn fueled an international scandal around the risks of GM

contamination to the environment. Editorial Note, *Nature,* vol. 416 (April 11, 2002) p. 600.

35 The July 2003 UK Government Science Panel Report (see note 31) found that it was "very unlikely [that GM crops] would invade the country-side and become problematic plants." However, the panel recommended that more research be conducted on the environmental effects of gene flow and on herbicide tolerance of GM crops.

36 Ibid.

37 Katie Eastham and Jeremy Sweet, *Genetically Modified Organisms: The Significance of Gene Flow Through Pollen Transfer* (Copenhagen, Denmark: European Environment Agency, 2003).

38 The Biosafety Protocol of the UN Convention on Biological Diversity entered into force in mid-2003. The objective of the Biosafety Protocol is to protect biological diversity from potential risks posed by living modified organisms resulting from biotechnology. The Protocol establishes an advanced information agreement to ensure that countries importing living modified organisms are able to make informed decisions prior to that importation taking place. Since the focus of the Protocol is on trade in living modified organisms, it is unclear if it would have any bearing on unintentional or accidental contamination. While Mexico has signed and ratified the Protocol, neither Canada nor the United States has done so.

39 For an insightful discussion of the relationship among trade liberalization, structural changes in markets, and vertical integration, see David Hummels, Jun Ishii, and Kei-Mu Yi, "The Nature and Growth of Vertical Integration in World Trade," *Journal of International Economics,* vol. 54, no. 1 (June 2001), pp. 75–96.

40 Rosamond Naylor, Walter Falcon, and Arthur Puente-Gonzalez, "Policy Reforms and Mexican Agriculture: Views from the Yaqui Valley," Economics Program Paper no. 01–01 (Mexico City: CIMMYT, 2001).

41 C. Ford Runge, "Feedlot Production of Cattle in the United States and Canada," in Sarah Richardson, ed., *Assessing Environmental Effects of the North American Free Trade Agreement: An Analytical Framework* (Montreal, Canada: North American Commission for Environmental Cooperation, 1999). See also Jerry Speir, Marie-Ann Bowden, David Ervin, Jim McElfish, and Rosario Perez Espejo, *Comparative Standards for Intensive Livestock Operations in Canada, Mexico, and the U.S.* (Montreal, Canada: North American Commission for Environmental Cooperation, 2002).

42 Jennifer Lee, "Neighbors of Vast Hog Farms Say Foul Air Endangers Their Health" *New York Times,* May 11, 2003, p. 1.

43 See Frank Ackerman, Timothy Wise, Kevin Gallagher, Luke Ney, and Regina Flores, "Free Trade, Corn and the Environment: Environmental Impacts of U.S.-Mexico Corn Trade under NAFTA," working paper no. 03-06 (Medford, Mass: Global Development and Environment Institute), June 2003. See also Chantal Line Carpentier, *Trade Liberalization Impacts on Agriculture: Predicted versus Realized"* (Montreal, Canada: North American Commission for Environmental Cooperation, December 2001).

44 Corn production in the United States is not only the biggest user of farmland, but also the greatest consumer of commercial nitrogen and phosphate fertilizers, making up 45 percent of total U.S. sales. In addition, U.S. corn production is a significant user of pesticides. The highest concentration of nitrogen pollution is found in the Mississippi River Delta—where more than half of total U.S. farm production is concentrated—where it moves over long distances and into the Gulf of Mexico. In recent years, incidences of hypoxic zones have increased in occurrence and severity. The main herbicide used in corn production is atrazine, which has been found extensively in groundwater wells. For a comprehensive review of the environmental effects of corn production, see C. Ford Runge, *King Corn: The History, Trade and Environmental Consequences of Corn (Maize) Production in the United States* (Washington, D.C.: World Wildlife Fund, 2002).

45 See, for example, Kym Anderson and J. Drake Brockman, *Trade and Environment Policy Issues: Implications for the Asia-Pacific Region* (Canberra, Australia: Australian Pacific Economic Cooperation Committee, 1995). Reprinted in abridged form in the *Business Council Bulletin,* vol. 118 (April 1995), pp. 46–53.

46 B. L. Turner et al., *Illustrating the Coupled Human-Environment System to Vulnerability Analysis: Three Case Studies* (Palo Alto, Calif.: Stanford University, 2003), available at www.pnas.org.

47 Enrique Aguilar, *Pricing of Irrigation Water in Mexico,* paper presented at the Irrigation Water Policies: Micro and Macro Considerations, World Bank, Agadir Morrocco, June 15–17, 2002, available at http://Inweb18.worldbank.org/ESSD/ardext.nsf/18ByDocName/eventsagadirconference2002.

48 Jose de Anda, Sergio Quinones-Cisneros, Richard French, and Manuel Guzman, "Hydrologic Balance of Lake Chapala," *Journal of the American Water Resources Association,* vol. 34, no. 6 (1998).

49 North American Commission for Environmental Cooperation, *The North American Mosaic* (Montreal, Canada: North American Commission for Environmental Cooperation, 2001).

50 Jorge Mattar, Juan-Carlos Moreno-Brid, and Wilson Peres, "Foreign Investment in Mexico After Economic Integration," (Mexico City: CEPAL-ECLAC, July 2002), www.networkideas.org/featart/sep2002mexico.pdf.

51 Antonio Yúnez-Naude and Fernando Barceinas Paredes, *The Agricultural of Mexico after Ten Years of NAFTA Implementation* (Washington, D.C.: Carnegie Endowment for International Peace, 2003), available at www.ceip.org.

52 A variable used by Yúnez-Naude and Paredes (see note 51) to estimate structural change in the fresh fruit and vegetable sector measures the value of agricultural monthly exports and imports (totals and per crop) in constant pesos using real exchange rate indexes for 1990. The discussion above also refers to structural changes outside this definition, including Schumpeterian definitions of market structure transformation and innovation, including vertical and horizontal integration.

53 The shift to intensive farming in the grains and horticulture sector may be much greater than the overall shift in the agricultural sector. Some studies suggest that the contribution that modern farms make to Mexico's GDP has remained roughly constant at between 27 and 35 percent since the early 1980s.

54 Dennis Henderson, "Between the Farm Gate and the Dinner

Plate: Motivations for Industrial Change in the Processed Food Sector," *The Future of Food* (Paris: Organization for Economic Cooperation and Development, 1999).

55 Favia Echanove Hacuja, "Working under Contract for the Vegetable Agro-Industry in Mexico," *Culture and Agriculture,* vol. 23, no. 3 (Fall 2001).

56 Lee Christensen, *Soil Nutrient and Water Management Systems in U.S. Corn Production* (Washington, D.C.: U.S. Department of Agriculture, April 2002).

57 See note 47.

58 Ibid.

59 Jose Maria Martinez, *Aquifers and Agro-Chemicals in a Border Region: NAFTA Challenges and Opportunities for Mexican Agriculture* (Montreal, Canada: North American Commission for Environmental Cooperation, 2003).

60 Travis Phillips, "Behind the U.S.-Mexico Water Treaty Dispute," report no. 77-7 (Austin, Texas: House Research Organization: Texas House of Representatives, April 30, 2002).

61 This does not include a net account of total water transfers in tomatoes, since the United States also exported tomatoes to Mexico, although at a much smaller level. As indicated in Figure 7, about 6.1 million metric tons of tomatoes were exported from Mexico to the United States from 1993 to 2001, or approximately 680,000 pounds per year. One metric ton of water is the equivalent of 265.617 gallons of water, making the average equivalent of exported water 180,656,632 gallons per year. Approximately 90 percent of all Mexican tomato exports on average are bound for the United States. A conservative, or lower bound, estimate therefore suggests that roughly 162 million gallons of freshwater equivalents are contained in these exports.

62 NAFTA and trade liberalization generally have affected farm size in Mexico in much the same way they have affected average farm sizes in the United States and Canada. According to the International Trade Commission, average farm size in the United States increased from 449 acres to 487 acres from 1978 to 1997, while the number of farms declined from 2.3 million to 1.9 million; U.S. International Trade Commission, "The Impact of Trade Agreements: Effect of the Tokyo Round, U.S.-Israel FTA, U.S.-Canada FTA, NAFTA and the Uruguay Round on the U.S. Economy," August, publication no. 3621 (Washington, D.C.: U.S. International Trade Commission, August 2003). See also *Trade and Environment Policy Issues,* note 45.

63 P. A. Matson, W. J. Parton, A. G. Power, and M. J. Swift, "Agricultural Intensification and Ecosystem Properties," *Science,* vol. 277, no. 25 (July 1997).

64 P. A. Sanchez, *Properties and Management of Soils in the Tropics* (New York: John Wiley & Sons, 1976).

65 Patricia Bouillon, Ariana Legovini, and Nora Lustig, *Rising Inequality in Mexico: Household Characteristics and Regional Effects* (Washington, D.C.: World Bank, September 2001). These authors show that the Gini coefficient increased from 49.14 to 54.91 between 1984 and 1994, and the mean-log deviation grew by 26 percent during the same period.

66 David Lee, Paul Ferrara, and Christopher Barrett, "Changing Perspectives on Agricultural Intensification, Economic Development and the Environment," in David R. Lee and Christopher B. Barrett, eds., *Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment* (New York: CABI Publishing, 2001), pp. 1–16.

67 *The North American Mosaic* (see note 49).

68 An insightful analysis of the history of public participation in Mexico's protected areas is provided in Martha Rosas, *Participatory Environmental Policy Processes: The Case of Advisory Councils in Protected Areas in Mexico,* unpublished thesis (England: University of Sussex, 2003).

69 David Pearce, *How Valuable Are the Tropical Forests* (paper presented at the Séminaire Développement Durable et Économie de l'Environmement, Paris, December 2001), available at www.iddri.org/iddri/telecharge/mardis/pearce.pdf.

70 One exception is payments for production of coffee, the largest export crop in Mexico. In 2002, annual payments through the Mexican Coffee Council of approximately US$100 million in coffee subsidies extended higher payments to all organic farms (the majority of which are small-scale), as well as higher payments for coffee grown in mountain regions. It is too early to tell if this subsidy structure is sufficient to reverse the effects of decades of payments that favored large coffee plantations.

71 ASERCA (Support Services for Agricultural Marketing) was created in 1991 and originally designed to provide support for farmers to pay for marketing expenses, such as storage and transportation. PROCAMPO (Farmers Direct Support Program) was created in 1994 and provides direct payments (decoupled income transfers) to farmers based on the size of their holdings. In response to criticism that they favor large-scale farms, reforms have been announced in July 2003 for ASERCA programs so that payments will cover all states, with varying farm sizes within states, for ten crops: maize, wheat, sorghum, sunflowers, canola, cotton, rice, soy, and two other crops used as grain feed for cattle.

72 B. L. Turner, J. Geoghegan, J. Eastman, D. Lawrence, and H. Vester, *Land Cover and Land-Change in the Southern Yucatan Peninsular Region: Refining Models and Projections of Deforestation with Application to the Carbon Cycle, Biotic Diversity, and Regeneration Capacity, Sustainability and Vulnerability,* available from the National Aeronautics and Space Administration at http://lcluc.gsfc.nasa.gov/products/pdfs/2003AnPrgRp/AnPrgRp_TurnerBL2003.doc.

73 See, for example, David Ervin, C. Ford Runge, E. Graffy, W. Anthony, S. Batie, P. Faeth, T. Penny, and T. Warman, "Agriculture and the Environment: A New Strategic Vision," *Environment,* vol. 40, no. 6 (July/August 1998), pp. 8–15, 35–40; Hakan Nordstom and Scott Vaughan, *Trade and Environment: Special Study* (Geneva, Switzerland: World Trade Organization, 1999).

74 See Karel Maynard, Stephanie Dionne, Marc Paquin, and Isaack Pageot-Lebel, *The Economic and Environmental Impacts of Agricultural Subsidies: An Assessment of the 2002 U.S. Farm Bill and the Doha Round* (Montreal, Canada: North American Commission for Environmental Cooperation, 2003); and Joseph Cooper et al., *Some Domestic Environmental Effects of U.S. Agricultural Adjustments under Liberalized Trade: A Preliminary Analysis* (Montreal, Canada: North American

Commission for Environmental Cooperation, 2003), both available at www.cec.org.

75 Campbell's began contract farming arrangements in Mexico in 1960, followed by Del Monte in 1962. Today, there are several frozen-food companies operating in Mexico, including Green Giant and Birdseye. See M. A. Barron and E. Rello, "The Impact of the Tomato Agro-Industry on the Rural Poor in Mexico," *Agricultural Economics,* vol. 23 (2000), pp. 283–97.

76 Between 1978 and 2001, U.S. growers received an increasingly smaller percentage of retail value for their produce, while the consolidation of the retail sector has meant that a higher share of retail value has gone to distributors and marketers. See *The Impact of Trade Agreements: Effect of the Tokyo Round, U.S.-Israel FTA, U.S.-Canada FTA, NAFTA, and the Uruguay Round on the U.S. Economy,* publication no. 3621 (Washington, D.C.: U.S. International Trade Commission, August 2003), available at www.usitc.gov.

77 Of the eighteen frozen-food companies operating in Mexico, 75 percent have their operations in Guanajuato. Roughly 10 percent of all vegetables grown in Mexico are from Guanajuato, which generates one-quarter of total agricultural revenues. Leading fresh crops are broccoli and cauliflower. In that state, approximately 18,000 hectares, on 580 farms, are cultivated under contract. Buyers with purchase contract arrangements include Green Giant and Birdseye. See "The Impact of the Tomato Agro-industry on the Rural Poor in Mexico," note 75.

78 Under the 1993 Foreign Investment Law, foreign ownership of banks was limited to 30 percent, increasing to 49 percent in 1996. In 1999, amendments allowed for full majority ownership by foreign interests. Similar reforms have been enacted by other Latin American countries, notably Colombia in 1979, Bolivia and Brazil in 1989, and Costa Rica in 1995. However, the changes in Mexico's laws have been the deepest.

79 World Bank, "Product Document for a Proposed Rural Finance Development Structural Adjustment Loan in the Amount of $505.6 million," report no. 25858 (Washington, D.C.: World Bank, May 16, 2003), available at www.worldbank.org. See also Emmanuel Baldacci, Luiz de Mello, and Gabriela Inchaute, "Financial Crisis, Poverty and Income Distribution," working paper no. WP/02/04 (Washington, D.C.: International Monetary Fund, 2002).

80 B. L. Turner et al., *Illustrating the Coupled Human-Environment Systems for Vulnerability Analysis: Three Case Studies,* March 2003, available at www.pnas.org.

81 World Bank, "World Bank Approves $505 Million Loan to Reform Banking Sector in Mexico," press release (Washington, D.C.: World Bank, June 13, 2003).

82 During 1991–1992, 55 percent (by area) of the production of wheat—the main crop in the Sonora region—was under *ejido* control, compared with 37 percent owned privately, and 8 percent rented by *ejidos* to private interests. By 1997–1998, 29 percent of wheat production was controlled by *ejidos;* 46 percent was controlled by the private sector and 25 percent was rented to private farming interests.

83 Rosamond Naylor, Walter Falcon, and Ivan Ortiz-Monasterio, "Policy Reforms and Mexican Agriculture: Views from the Yaqui Valley," CIMMYT Economic Program Paper no. 01-01 (Palo Alto, Calif.: Stanford University, 2001), available at http://yaquivalley.stanford.edu/publications.

84 Ibid.

85 R. Constanza, D. Arge, R. de Groot, S. Faber, M. Grasse, B. Hannon, K. Limburgh, S. Naeen, and R. O'Neil, "The Value of the World's Ecosystem Services and Natural Capital," *Nature,* vol. 387 (1997), pp. 253–60.

86 The three general approaches to economic valuation are (a) estimates of averted behavior; (b) hedonic pricing estimates, using changes in real estate-type prices as a proxy; and (c) contingent valuation, based on questionnaires of the willingness-to-pay (WTP) type. Approaches generally give some proxy of the total economic value (TEV) of the environmental resource being valued, based on the following stylized estimate: TEV = direct use value + indirect use value + option value + existence value.

87 A. C. Fisher and W. M. Hanemann, *Option Value and the Extinction of Species* (Berkeley, Calif.: California Agriculture Experiment Station, 1985).

88 Scott Vaughan, Chantal Line Carpentier, and Zachary Patterson, *Mexico and Emerging Carbon Markets: Investment Opportunities for Small and Medium-Sized Companies* (Montreal, Canada: North American Commission for Environmental Cooperation, 2000).

89 The main demands of the farmers included a moratorium on all agricultural provisions of NAFTA, emergency and long-term agricultural development programs, viable rural credit institutions, government investment in rural infrastructure and communities, food safety and quality for consumers, and recognition of the rights of indigenous peoples.

90 Alan Winters, "Trade Liberalization and Poverty: What Do We Know?" *GTAP Working Papers,* (West Lafayette, Ind.: Purdue University, June 2003), available at www.gtap.org. See also William Easterly, *The Elusive Quest for Growth* (Cambridge, Mass.: MIT Press, 2002); and World Bank, *Globalization, Growth and Poverty: Building an Inclusive World Economy* (policy research report) (Washington, D.C.: World Bank, 2002).

91 The author is grateful to Dan Biller, World Bank Institute, for this insight regarding benefits transfers.

92 Daniele Giovannucci, *Sustainable Coffee Survey of the North American Specialty Coffee Industry* (report prepared for the Nature Conservancy, the Summit Foundation, the NACEC, the Specialty Coffee Association, and the World Bank, July 2003), available at www.cec.org.

93 A. Brezinski and Scott Vaughan, *Measuring Consumer Interest in Shade-Grown Coffee: An Assessment of the Canadian, Mexican and U.S. Markets* (Montreal, Canada: North American Commission for Environmental Cooperation, 1999).

94 A long-standing challenge for developing-country exporters attempting to differentiate products in the marketplace involves the cost of often multiple certification and labeling schemes to convey to consumers some environmental characteristics of sustainable products. Mexico's biological diversity research and policy group (CONABIO) recently has explored highly innovative ways of using geographic indicators to distinguish, for consumers, different sustainable products being produced in rich ecosystem areas such as Chiapas.