Analytic Framework
for Assessing the Environmental Effects of the North American Free Trade Agreement

Commission for
Environmental Cooperation

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4 **Building a Framework for Assessing NAFTA Environmental Effects:** Report of a Workshop held in La Jolla, California, on April 29 and 30, 1996
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Foreword

The North American Agreement on Environmental Cooperation (NAAEC) [Article10(6)(d)], directs the Commission for Environmental Cooperation (CEC), to consider on an ongoing basis the environmental effects of the North American Free Trade Agreement (NAFTA). A NAFTA Effects Project Team was assembled to assist the CEC in designing a methodology to fulfill this mandate. The following Analytic Framework is the culmination of the collective work of these North American experts over the course of four years.

This Analytic Framework has been developed in three distinct phases. In Phase I (1995–1996), an interdisciplinary group of experts undertook research to explore the trade and investment regime that NAFTA put in place, and the ways that NAFTA-associated economic change might relate to the environment, in order to develop the preliminary analytical approach to fulfill the mandate of the CEC under Article 10(6)(d). Before beginning Phase I, the CEC surveyed other attempts to assess the effects of economic activity and trade on the environment, identified other organizations working on these issues, and examined the claims that had been made prior to NAFTA about what the public and interested parties believed might be the Agreement's major effects—both positive and negative (CEC 1996c, 1996d). These background studies helped the CEC set its work in context and identify appropriate stakeholders.

The methodology was subsequently designed to develop an understanding of the connections between trade and the environment, to assist in anticipating important environmental impacts in the context of trade liberalization, and to develop policy tools to better mitigate negative impacts and maximize positive ones. The work undertaken in Phase I was subject to public comment at a meeting in La Jolla in April 1996. The proceedings from that workshop were published by the CEC (CEC 1996a). Phase I was further informed by the results of the consultations on trade and environment by the Joint Public Advisory Committee (JPAC) in the spring and summer of 1996.

Phase II (1996–1997) of the project built on the basic approach developed in Phase I, as refined on the basis of review and consultation. Phase II also took into account the work done by international organizations, such as the Organization for Economic Cooperation and Development (OECD), and by research and other communities in the NAFTA region and beyond, on trade-environment linkages. During Phase II, the Framework was further elaborated using the analysis of four component studies:

- an examination of the operation of NAFTA's environmentally-related institutions,
- an issue study on maize in Mexico,
- an issue study on cattle feedlots in the United States and Canada, and
- an issue study on electricity in Canada, the United States and Mexico.

The first study, entitled *NAFTA's Institutions: The Environmental Potential and Performance of the NAFTA Free Trade Commission and Related Bodies* (CEC 1997b), was designed to address a wide range of economic, social and government policy changes through an analysis of the work of the institutions created by NAFTA. The subsequent three issue studies were designed to test and refine the methodology, with a particular emphasis in Phase II on understanding and

developing the linkages between economic activity and the environment. During Phase II, the CEC received feedback from experts and stakeholders through two workshops that considered the issue studies and the general framework. The workshops were designed to present the ongoing research and analysis to an audience of experts in the specific sectors for their review and comment. The issue studies played a vital role in developing the Framework for Analysis (Phase II). At their fourth Regular Session, in June 1998 in Mérida, the CEC Council announced that the Framework and Issue Studies representing Phase II of the project would be released to the public. The document was translated and released in the three NAFTA languages in March 1999 (CEC 1999).

Phase III of the project (1998–1999) consisted, in the first instance, of an extensive peer review of the work undertaken in Phase II, and the subsequent incorporation into the methodology of comments provided. This document reflects the culmination of that process. It also includes a preliminary review of indicators for incorporation into its final section. The Analytic Framework consists of two major components: the first, Part I, is a methodological framework for analysis that should serve as a guide for individuals or organizations seeking to apply this methodology; the second, Part II, is a background on methodological and empirical issues associated with the methodology. This second component is designed to provide more detail on a number of the main areas covered in the Framework, and includes results of research and analysis undertaken over the course of developing the methodology. The division of the framework into these two components was one of the key recommendations put forward by the peer reviewers.

The central purpose of the NAFTA Effects Project has been to develop a methodology that can be applied on an ongoing basis to particular issues and sectors of concern in the NAFTA community. To this end, individuals and organizations will be encouraged to undertake independent analyses using the Framework, in preparation for a North American Conference on Issues Related to Environment and Trade, that will be sponsored by the CEC in September 2000. It is hoped that the work presented in that forum will further enrich the research and analysis contained herein, thereby increasing capacity to identify and understand the linkages between trade liberalization and the environment, and improving the capacity of governments and others to use these linkages in ways that promote the goals of both issue areas simultaneously.

Acknowledgments

This document is the collective work of a number of individuals representing a broad range of different sectors, who have been assembled by the Commission for Environmental Cooperation (CEC) at various times in the past four years to help it fulfill its mandate to develop a framework to assess the effects of NAFTA on the environment. The CEC is grateful to all of these individuals for their important contributions to this project.

First, the CEC would like to thank the members of the NAFTA Effects Project Team who have included, over the past four years, the following individuals: John Kirton, Department of Political Science, University of Toronto; Raúl García Barrios, *Professor e Investigador, Centro de Investigación y Docencia Económica*; Virginia Maclaren, Department of Geography, University of Toronto; Omar Masera, *Centro de Ecología, Universidad Nacional Autónoma de México*; Rogelio Ramírez de la O, *Director General, Ecanal* S.A. de C.V.; Sidney Weintraub, Centre for Strategic and International Studies; David Wilk Graber, *WG Consultores y Asociados*, S.A. de C.V.; Ralph Cavanagh, Natural Resources Defense Council, San Francisco; Rafael Fernández de Castro, *Instituto Tecnológico Autónomo de México* (ITAM); Dermot Foley, Association for the Advancement of Sustainable Energy Policy, Vancouver; Glenn Fox, Department of Agricultural Economics and Business, University of Guelph; Edward Hoyt, *EIC de México*, S.A. de C.V.; John Paul Moscarella, Econergy International Corporation (EIC), Washington, DC; Alejandro Nadal, Professor, Center for Economic Studies and Science and Technology Program, *El Colegio de México*; Carol Reardon, Heenan Blaikie, Vancouver; C. Ford Runge, Distinguished McKnight University Professor of Applied Economics and Law, Department of Applied Economics, Center for International Food and Agricultural Policy, University of Minnesota.

Research assistance was provided at various points during the past four years by the following individuals: Julie Soloway at the Centre for International Studies in Toronto; Jan Gilbreath at the University of Texas in Austin; Enrique Velasco-Ibarra at Johns Hopkins School of Advanced International Studies in Washington, DC; Ashley Prince at the University of South Florida; Tim Egan (Toronto); Mary Vanderbilt (Washington, DC); Olga Sandoval García (México, DF); Cecilia Brain; Michael P. Ivy; Marcos Chávez Maguey; and Francisco Aguayo.

A number of people assisted the CEC and the Project Team during Phase I of this project, assembling and analyzing critical background material. Notably, we owe thanks to Dan Esty of Yale University for his assessment, in 1995, of attempts to model the effects of trade and economic activity on the environment, and Mark Spalding and Marc Stern from the University of California, San Diego, who, in 1995, prepared an index of potential NAFTA effects that were identified during the policy debates surrounding NAFTA in 1991–1994.

In Phase II, important contributions to the work on NAFTA's institutions were made in 1997 by Sanford Gaines of the University of Houston; John Audley, from the National Wildlife Federation; Armand de Mestral, in the Faculty of Law at McGill University, and Raoul Hinojosa, a professor of Economics at the University of California at Los Angeles. Additional contributions were made to the issue studies in Phase II by Rafael Ortega Paczka, of the *Universidad Autónoma de Chapingo*; Antonio Turrent, from the *Colegio de Posgraduados* and INIFAP; Rocío Alatorre, from the *Instituto de Salud, Ambiente y Trabajo* (ISAT); Carlos Salas

Páez, from the Science and Technology Program at *El Colegio de México*; and Víctor Suárez of the *Asociación Nacional de Empresas Comercializadoras de Productos del Campo* (ANEC).

An important component of Phase III of this exercise has been the extensive peer review conducted by individuals from the three NAFTA countries. The CEC would like to thank the reviewers for their thoughtful comments. They include, from Canada, Yvan Bernier, *Faculté de Droit, Université Laval*; Peter Victor, Faculty of Environmental Studies, York University; Mike Beale, Environment Canada; John Curtis, Department of Foreign Affairs and International Trade. From Mexico, Rolando Cordera, Nexos TV; Carlos Muñoz Piña, University of Berkeley; Anil Markandya, University of Bath; José A. Canela-Cacho, University of California at Berkeley. And finally, from the United States, Robert Shackleton, US Environmental Protection Agency; Scott Nance, Colby & Nance; Michael Ferrantino, US International Trade Commission; and Richard Boltuck, Trade Resources, Co.

The CEC has received generous institutional support at important points during the course of this project from the following institutions: Centre for International Studies at the University of Toronto; the Johns Hopkins University School of Advanced International Studies, in Washington, DC; the Center for Strategic and International Studies, in Washington, DC; The Institute of the Americas, in La Jolla, CA; The National Round Table on the Environment and the Economy, in Canada; and *El Colegio de México*. We have been privileged to work with institutions in the three NAFTA countries that play such distinctive roles in the policy debate on issues related to the environment and the economy in North America.

In addition, there are a number of individuals from environmental groups, business organizations and governments, who have made themselves available to the CEC and to individual members of the Project Team for the series of specialized interviews that form an important part of the research for this project, and who have provided advice to the CEC over the life of this project. These groups include the National Advisory Groups, set up under NAAEC, who advise the CEC Council on program-related issues. The CEC would also like to thank the individuals who took the time to participate in the public consultation in La Jolla in 1996, and in the expert workshops held in Montreal in 1997, to discuss the issue studies and the framework. Public interest, commentary, and feedback have been critical in assisting the CEC to develop and refine its work and bring this project to its final phase.

Finally, the CEC gratefully acknowledges the work of the NAFTA Effects Advisory Group: Pierre Marc Johnson (Chair), Heenan Blaikie, Montreal; Alicia Barcena, Advisor, UNEP-Mexico; León Bendesky, Director, ERI Consultants, Mexico; Pierre Goselin, *Comité de santé environnementale du Québec*; William Haney III, President, Molten Metal Technologies; Kenneth Harrigan, Past Chair and CEO, Ford Motor Company of Canada; Gary Hufbauer, Council on Foreign Relations, New York; Richard Kamp, Director, Border Ecology Project; Elizabeth May, Executive Director, Sierra Club of Canada; Jack McLeod, Corporate Director (former CEO), Shell Canada; Edmund Miller, Mott Foundation; José Montemayor Dragonné, Commercial Director, *Química Pennwwalt*, S.A. de C.V., Mexico; Robert Repetto, Vice President and Chief Economist, World Resources Institute; Hilda Salazar, President, *Grupo Desarrollo-Ambiente*; Víctor Urquidi, Professor, *El Colegio de México*. The individuals on the Advisory Group, and past members, including Philip Shabecoff, Editor, *Greenwire*; and Víctor Toledo, *Centro de Ecología*, UNAM, have volunteered their time, assisting the CEC to enrich this work.

The Framework at a Glance

Six preliminary hypotheses to focus the analysis

1. Does NAFTA reinforce existing patterns of comparative advantage and specialization to the benefit of efficiency?
2. Does NAFTA trade liberalization lead to a regulatory/migratory "race-to-the-bottom"?
3. Does NAFTA give rise to competitive pressures for capital and technological modernization?
4. Do liberalized rules under NAFTA serve to increase the use of environmentally friendly products?
5. Does NAFTA lead to upward convergence of environmental practice and regulation through activities of the private sector?
6. Does NAFTA lead to upward convergence of environmental practice and regulation through activities of the various levels of government, and if so, how?

Framework application

I. Select the sector to be studied
II. Select the specific issues for study within or across sectors
III. Establish connection of sector/issue to NAFTA
    A. NAFTA rule changes
        1. Tariff reductions and other border measures
        2. Changes affecting goods/services once imported
        3. Inputs
        4. Substitute products
        5. Norms for particular processes
        6. Preambular principles and stated objectives
        7. National implementing legislation
        8. Accelerated tariff reduction
    B. NAFTA's institutions
        1. Meeting mandatory responsibilities
        2. Acting upon discretionary environmental mandates
        3. Extending to other relevant subjects
        4. Generating new institutions
        5. Fostering communication
        6. Capacity building
        7. Discouraging unilateral action
        8. Fostering high levels of environmental convergence
        9. Participating multilaterally
        10. Contributing to community building and identity
    C. Trade flows
        1. Value and volume of exports/imports
        2. Market share
        3. Structure and composition
        4. Creation and diversion
    D. Transborder investment flows
        1. Regional concentration of investment
        2. Sectorial investment shift, migration and subsidies

7. Trilateral cooperation at various governmental levels outside NAFTA institutions

V. Indicators of environmental impacts stemming from NAFTA

A. Air indicators
1. Acid precipitation (SO_x)
2. Ozone concentration (O_3, NO_x, VOCs)
3. Particulate matter (PM_{10}, $PM_{2.5}$, Hg, Pb)
4. Persistent organic pollutants (POPs)
5. Carbon monoxide (CO)
6. Carbon dioxide (CO_2)

B. Water indicators
1. Quality of drinking water
2. Freshwater use (by source/sector)
3. Lead concentration
4. Copper concentration
5. Surface water pollutants
6. Fish capture
7. Sewage treatment connection rates

C. Land indicators
1. Intensity of pesticide use for agriculture
2. Nitrogen from fertilizers and livestock
3. Area of forested land
4. Intensity of forest use
5. Waste generation
6. Recycling rate

D. Biodiversity indicators
1. Number of threatened/extinct species
2. Wetlands
3. Protected areas

E. Aggregate indicators
1. Climate change
2. Ozone depletion
3. Acidification
4. Eutrophication
5. Cost of environmental remediation
6. “Ecological footprint”
7. Energy intensity
8. Human health costs of environmental pollution
9. Energy mix
10. Biological integrity

Part I: Analytic Framework for Assessing the Environmental Effects of the North American Free Trade Agreement

I. Introduction to Framework Analysis

This document presents the final version of an Analytic Framework that has been developed under the North American Free Trade Agreement (NAFTA) Environmental Effects Project, within the Commission for Environmental Cooperation's (CEC) Environment, Economy and Trade Program. The overall goal of this project has been to advance the understanding of the relationship between the environment, economy, and trade in the North American region, in order to promote increased cooperation and dialogue, and strengthen environmental protection among the NAFTA Parties. The CEC recognizes the importance of understanding the relationships between environment, economy and trade to highlight positive relationships and mitigate any negative ones. Such increases in knowledge and analytical capabilities will allow governments and other interested parties better to identify and address these linkages.

The Analytic Framework presented in this document has evolved over three years of study and discussion. It is supported by a background document that includes the empirical evidence and analysis underpinning the methodology used here. In short, this framework is a tool that puts forward hypotheses suggesting relationships between trade and the environment and, in the specific context of NAFTA, provides a methodology for analysis and suggests variables for empirical study, in order to confirm or refute existing hypotheses or generate new ones. The overall goal of this exercise is to develop an improved understanding of the linkages between trade liberalization and the environment.

The NAFTA Environmental Effects Project, and the Analytic Framework it has produced, responds directly to Article 10(6)(d) of the North American Agreement on Environmental Cooperation (NAAEC). This article prescribes cooperation between the CEC Council and the NAFTA Free Trade Commission, to achieve the environmental goals and objectives of NAFTA by assessing, on an ongoing basis, its environmental effects

For the purposes of this analysis, "NAFTA" (or the "NAFTA regime") is defined broadly as comprising the three agreements (The North American Free Trade Agreement, the North American Agreement on Environmental Cooperation, the North American Agreement on Labor Cooperation) that took formal effect on 1 January 1994, covering trade, investment, environment, and labor. This definition further includes the principles embodied in, and institutions created or catalyzed by, these international agreements.

This document does not offer a definitive judgment about NAFTA's environmental effects to date. The lack of knowledge about important variables and relationships, the absence of reliable comparative baseline data, and the relatively short time NAFTA has been in effect mean that such conclusive, comprehensive judgment is not yet possible. However, the Analytic Framework has now been developed to the point where its empirical application is both possible and appropriate. It is hoped that it will be applied, using the NAFTA model, to generate such judgments, thereby enriching the methodology, the state of knowledge, and the analytical understanding in North America of the relationships between the environment, the economy and trade.

A. Major Hypotheses to Focus the Analysis

On a general level, six major hypotheses can serve as arguments to guide the application of this framework. These are not assumptions intended to predispose the analysis in a particular direction. Rather, they are hypotheses that together should serve to direct the analysis in a disciplined fashion; each to be individually supported, refuted or modified as the evidence suggests. These hypotheses suggest views about how NAFTA might affect the North American environment through economic, social and political processes. They are based on the work and literature about relevant relationships between the environment and the economy, on the variables presented in the framework and, where possible, on the diagnostic empirical applications conducted in this project. It is hoped that they will aid the analyst to tie together the particular variables and relationships identified in the framework, and address important areas of possible environmental effects.

1. ***Specialization and Efficiency:*** *Does NAFTA-induced liberalization reinforce existing patterns of comparative advantage and specialization, concentrating production and transportation where it takes place most efficiently*?

   New economic activity may be concentrated in sectors and firms operating by methods, in locales, and through transportation networks where environmental conditions are most favorable and regulatory oversight the strongest. Because of their size, profitability and visibility, such firms can develop, incorporate and diffuse state-of-the-art technology, and adopt high environmental standards, both on a voluntary basis and in anticipation of governmental inspection/enforcement action. Conversely, liberalization may concentrate economic activity in sectors, firms or geographic areas unsupported by adequate technology, management, physical infrastructure or the institutional capacity to handle NAFTA-induced growth, and where ecological stress is already acute.

2. ***Regulatory/migratory "race-to-the-bottom":*** *Does economy-wide liberalization associated with NAFTA intensify competitive pressures throughout the region, leading firms to lower their environmental regulatory burden?*

   Competitive pressures may lead firms to lower input costs, in part by reducing environmental protection or by pressuring governments to lower costly environmental standards. Some firms might move production to jurisdictions with lower standards, or shift to less costly and less environmentally friendly sources of supply. The resulting "race-to-the-bottom" can, absent offsetting policy intervention, create an economy-wide incentive to more highly polluting production throughout the region. Alternatively, it can induce firms, as part of their corporate strategy, to engage in cost-reducing environmental innovation, and to urge their governments to introduce new, more stringent environmental regulation that supports the new production methods.

3. ***Competitive capital and technological modernization:*** *Does liberalization lead to the economic growth that promotes industrial modernization and reduces environmental stress?*

   NAFTA-induced growth and competitive market pressures generated by liberalization can hasten processes of capital and technological modernization for all firms. The newly opened NAFTA marketplace can provide the revenue and the income to allow firms to accelerate

capital turnover, and invest in cleaner, more efficient plants, technologies and processes. In the process, however, this new marketplace may harm the even more environmentally friendly and socially valuable traditional methods. Government policy may enhance or impede both processes.

4. ***Increased use of environmentally friendly products:*** *Do NAFTA's liberalizing rules in specific sectors and products lead to the greater use of imported environmentally superior products as substitutes for less-clean domestic alternatives?*

   NAFTA's rules can reduce, or allow for the reduction of, barriers on relatively clean products and services and/or on relatively clean inputs. At an economy-wide level, such substitution can lead to a shift of production and consumption to those sectors and products with lower tariffs that generate less environmental stresses. Government policy and political processes committed to maximizing the environmental benefits of trade liberalization can be instrumental in ensuring that this occurs to the greatest extent possible.

5. ***Private sector-led upward convergence of environmental practice and regulation:*** *Does NAFTA-associated liberalization affect corporate practice and subsequent government policy by creating an upward movement of environmental standards and regulations toward a common, high, regional norm?*

   This dynamic may arise on an ad hoc individual or collective, voluntary, private-sector basis. NAFTA liberalization can intensify the need for companies to access the larger North American market and to operate production systems that are integrated region-wide. Industry leaders may build and operate to meet the highest standards in any of the three countries. They may create a single, industry- and supplier-wide set of environmental standards covering their operations in all three jurisdictions in order to lower their transaction costs. The private sector may also be leaders in implementing environmental management systems that meet international standards, such as ISO (International Organization for Standardization) 14000. This can have the dual effect of facilitating trade liberalization, while at the same time raising levels of environmental protection. Governments can adjust their policy and regulation to reflect and reinforce this evolving corporate practice.

6. ***Government-led upward convergence of environmental regulation and practice:*** *Is upward regulatory convergence being led by the governments through individual adjustment, on a negotiated basis, or through NAFTA's trilateral institutions?*

   NAFTA can induce the federal governments in North America to engage in communication, capacity building, regional regulatory convergence, and cooperation as a region. By involving other stakeholders, it may, over time, create transnational coalitions and a sense of community that leads to regional standards, practices, awareness, and a sense of collective responsibility. The institutional structures created and catalyzed by NAFTA can also assist social organizations and civil society to present governments with demands for enhanced environmental performance. The NAFTA regime features dispute settlement and surveillance mechanisms that may also encourage and assist governments to engage in stronger environmental performance. In addition, such a dynamic might encourage the NAFTA

countries to approach wider international fora, and adopt multilateral approaches that support the particular environmental requirements of North America.

B. Applying the Framework Analysis

To achieve its objective, the analytical methodology of the framework may be applied both generally and specifically to issues or sectors. The component sections of the framework examine the NAFTA regime and associated trade and investment flows (**§§ III. A–E**, below), and trace four major processes through which activity generated or affected by NAFTA's rules and institutions impact the region's environment (**§§ IV. A–D**, below). In addition to the six overall hypotheses identified above, the framework specifies the content of key variables relating to rules, institutions, trade, investment, production management and technology, physical infrastructure, social organization, government policy, air, water, land and living things.

This framework also identifies, through various techniques, relationships among these variables at a general or sectoral level, where there may be an important connection between NAFTA and the environmental concerns of its Parties (**§ V**). The framework can be applied to specific sectors (and firms or locales within them), to priority trade-environment issues in North America, or to the North American region as a whole. It can also be applied using qualitative or quantitative evidence, through case studies or formal economic and/or ecological modeling techniques.

Level of Application

The analytical methodology of the framework can be applied most readily at an intermediate level by examining NAFTA-associated change in specific sectors of North American industry, and to important economic or environmental issues that arise within a sector or across a wide variety of sectors.

The following criteria should serve as a guide for the selection of sectors, to maximize an overall understanding of NAFTA's environmental effects.

- The sector relates directly to major environmental media and natural resources.
- The sector has been the subject of changes in the economic rules set by NAFTA.
- The sector has experienced changes in trade during the post-NAFTA period.
- The sector has involved new, direct foreign investment among NAFTA Parties since 1994.
- The sector is one where one might expect, *a priori*, that there are important effects attributable to NAFTA.

Criteria to identify specific issues within or across sectors are as follows:

- The issue relates directly to major environmental media and natural resources.
- The issue is significant from an environmental perspective.
- The issue bears some significant relationship to the integration of the North American economy through NAFTA rule changes, government policy changes, institutional changes, investment changes or direct trade impacts.
- An analysis of the issue contributes to an understanding of other issues of importance in North America.

- An analysis of the issue contributes to tracing linkages between NAFTA and its relative impact on the ambient environment.

In exploring specific sectors and issues, it is necessary to set clear boundaries on the field of analysis. In some cases, it is useful to trace the entire production and value chain of a specific sector or issue, in a "cradle-to-grave" sequence, to develop a full life-cycle analysis that includes consideration of elements such as drains on ecological capital, through to ultimate use and disposal. At a minimum, the boundaries should be able to expand to include changes in the major upstream (inputs) or downstream (products) sectors or issues with which they are linked. Such expansions of the field of analysis should be guided by the following criteria:

- Is there a related sector or issue that is a major input into and/or consumer of the sector or issue under consideration?
- Are there related economic or environmental dynamics from other issues or sectors that are necessary to the operation of the sector under consideration?
- Is there a related sector or issue that has proliferating ecological impact on the sector or issue under consideration?

Methods for Analysis

This analytical framework can be applied through various methodologies, alone or in combination. These comprise qualitative (even anecdotal) and quantitative methods, including partial and general equilibrium, economic and ecological modeling. In all cases, they should integrate the major variables that appear in the framework, including legal, economic, institutional, social, political and ecological factors.

At present, the framework can be most readily applied by using qualitative and selected quantitative methods. The former, based largely on specialized interviewing techniques, are particularly useful for examining legal, institutional, technological and social factors, as well as components relating to management, production, and policy. A reliance on existing quantitative material is most useful to identify trade and investment flows, physical infrastructure and changes in the ambient environment.

Partial or general equilibrium models of the economy, based only on quantitative methods, are still of limited use for assessing NAFTA's environmental effects. There are important components of the North American economy, such as technology and foreign direct investment, that have not been directly incorporated into existing economy-wide economic models applicable for an assessment of NAFTA effects.

Nevertheless, some partial equilibrium models do show promise as having important application for specific variables in the analysis. At present, particularly as applied to the agricultural sector, partial equilibrium models are used successfully to indicate how changes in trade are affected by macroeconomic forces. Combined with other variables in the framework, these models can trace and produce a relatively accurate account of NAFTA-induced changes in trade flows.

Existing quantitative models are generally less useful in relating economic change to environmental factors. While some helpful work is available correlating sectoral changes in trade

and investment with the pollution intensities of those sectors, such analyses still do not incorporate important differences in production and technology among the three NAFTA countries, or other intervening processes, such as those identified in the framework.

Efforts to realize the potential of quantitative models should focus on generating required data from all NAFTA countries, linking trade with environmental indicators, and identifying how the different processes unleashed by NAFTA-associated trade liberalization affect the environment in distinct ways. The existing, limited state of such modeling efforts should not deter or delay efforts to build new models or applications relying on other quantitative or qualitative techniques.

II. The Broader Context

The environmental impact of an activity will often be determined by a range of forces, many unconnected to NAFTA. It is thus necessary to identify and take into account, throughout the analysis, the environmental, economic, social, geographic and political factors that have an important effect on a particular issue or sector.

III. The NAFTA Connection

The next step is to consider how NAFTA is connected to the sector or issue under consideration.

Although NAFTA came into formal effect on 1 January 1994, it is a dynamic regime that began to influence economic life in the region from the time it first emerged as a possibility in 1990. It is a regime that confirmed, as well as changed, existing rules, and one whose institutions are steadily expanding the content and force of the initial rules of the Agreement. Indeed, NAFTA might well offer an instrument to address environmental issues, and serve ecological opportunities that are not otherwise directly associated with it.

It is in the spirit of environmental enhancement and the precautionary principle—both of which are integral to the principle of sustainable development that NAFTA promotes—that this broad conception of NAFTA is adopted. To identify the NAFTA connection, the framework offers the following key areas for consideration:

- NAFTA rule changes,
- NAFTA's institutions,
- trade flows,
- transborder investment flows,and
- other economic conditioning forces.

Within this configuration, NAFTA may be associated with economic, social, political and environmental change in several ways. In some cases, NAFTA's provisions might have a direct effect on the environment, while in others its impacts will be less direct. In certain instances, NAFTA may have little visible impact upon economic or ecological activity, given processes already underway in the private sector, the wider economies, or other international agreements;

but it can serve to codify and reinforce these existing or emerging practices, or be critical in steering them in particular directions.

A. NAFTA Rule Changes

NAFTA's rules are those specified in the agreement itself, in its tariff annexes, and in its two companion agreements. A number of important variables should be examined in order to obtain a comprehensive picture of the impact of specific NAFTA rules on any given product, service, or sector.

The specific rules of greatest relevance are the following:

1. ***Tariff reductions and other border measures***. These include tariffs, quotas, quantitative restrictions, and rules of origin. These reductions should be assessed according to:

- the base-level tariff among the three countries prior to NAFTA;
- the degree and timing of liberalization already scheduled to take place according to other trade agreements and unilateral national action;
- the particular NAFTA tariff phase-out schedule; and
- the tariffs that NAFTA Parties maintain and face with non-NAFTA countries.

2. ***Changes affecting goods/services once imported***. These include changes in NAFTA rules on behind-the-border or domestic issues that may affect trade flows. It also includes changes in product standards.

3. ***Inputs.*** This refers to tariff reductions and other border measures affecting major inputs to relevant products and goods. These changes affect price and therefore demand for inputs and determine the mix of inputs used in the production chain.

4. ***Substitute products.*** This refers to tariff reductions and other border measures affecting "like" or substitute products.. Rule changes affecting a particular product or sector must be considered relative to changes in related products and sectors among NAFTA countries and with their other trading partners. Full account must be taken of the possibility of substitutions encouraged by the differential reduction of tariffs and other trade barriers.

NAFTA also includes general rules which, while they do not explicitly apply to a single product or sector, discipline the means or processes by which products and services (and their inputs) in all sectors across the economy are produced, sold or purchased. The following variables are relevant to determine the impact of more general NAFTA rules that discipline behavior on an economy-wide basis:

5. ***Norms for particular processes.*** Such norms include the Article 1114 disciplines on investment, risk assessment, sanitary and phytosanitary standards, health and safety standards, procurement policies, and investment guarantees.

6. ***Preambular principles and stated objectives.*** NAFTA's stated objectives include the promotion of sustainable development and strengthening of environmental regulation and enforcement.

7. ***National implementing legislation.*** This is legislation required in the three countries for NAFTA and its related agreements to take force, including agreements subsequent to NAFTA itself, such as the Canadian intergovernmental agreement governing provincial participation.

8. ***Accelerated tariff reduction.*** These are those rules generated by the NAFTA institutions or those reached intergovernmentally subsequent to the Agreement coming into force, and the cumulative overall reduction of tariffs and trade and investment barriers, including future specified liberalization, that parties can anticipate and adjust to in advance.

B. NAFTA's Institutions

NAFTA's institutions are the 26 trilateral intergovernmental commissions, committees or working groups created directly by NAFTA and its related agreements, and the similar number catalyzed by them since 1 January 1994. These institutions are designed to implement and extend the agreements. The operation of these institutions can affect the application and result of NAFTA's rules, even when the latter come with very precise targets and timetables.

There are a number of institutions that can be included in the present examination, as identified below. In all cases, it is important to consider the relationship of these institutions with national regulatory and government authorities, which retain significant capacity and whose intergovernmental cooperation outside NAFTA institutions has substantial effects.

The NAFTA institutions of greatest relevance to the environment are:

- the Council of the Free Trade Commission (FTC),
- the Council of the Commission for Environmental Cooperation (CEC),
- the Council of the Commission for Labor Cooperation (CLC),
- institutions created by NAFTA with mandatory environmental responsibility,
- institutions created by NAFTA whose subject matter has an inherent environmental relevance, and
- NAFTA's dispute settlement, avoidance and surveillance mechanisms.

To assess the impact of these institutions, it is important first to focus on their development as trilateral entities and their specified purposes, programs, resources and decision-making procedures. Further, it is useful to examine each in accordance with how it performs the following functions: to foster the growth of the NAFTA regime, balance the interests of the three countries and the trade and environment communities, and promote sustainable development. Variables that should be considered within relevant institutions include how they are accomplishing the following:

1. ***Meeting their mandatory responsibilities***. These are the areas where the rules specify that a NAFTA institution "shall" act in a prescribed way, often to meet a specified target with a precise timetable attached.

2. ***Acting upon their discretionary environmental mandates*.** The institutions may act on the discretionary, environmentally-related mandates set forth in NAFTA or its related agreements, such as those where the Parties "may" rather than "shall" act on environmental issues.

3. ***Extending to other relevant subjects***. The institutions may include within the trilateral process additional subjects and issue areas beyond those specified in the initial agreements.

4. ***Generating new institutions*.** The institutions may perform a role in catalyzing other bodies or processes as part of, or outside, the NAFTA structure of institutions.

5. ***Fostering communication.*** This includes communication through an open exchange of information and learning. Such communication makes it easier to understand and meet national standards, leads to transparency and trust, and fosters a sharing of best practices.

6. ***Building capacity.***. This is done by sharing resources of a financial, material and intellectual nature. Institutions can lead national governments to offer environmentally enhancing equipment and training to their NAFTA partners.

7. ***Discouraging unilateral action.*** Norms developed in institutions can lead to a reluctance to use national restrictive measures and can allow problems to be collectively resolved at an early stage. This would include how institutions act to constrain unilateral use of discretionary national regulatory and compliance measures.

8. ***Fostering high levels of environmental convergence.*** NAFTA's institutions can encourage the adjustment of specific national regulations to more compatible or convergent levels, and foster new single region-wide regulations where none existed before.

9. ***Participating multilaterally.*** The institutions may strengthen cooperation among the three North American countries as they participate in broader multilateral forums. They may thus be extending the geographic relevance of NAFTA's work through its impact on outsiders (including use as a model), and by developing complementary North American positions and consultations in outside forums.

10. ***Contributing to community building and identity.*** The institutions may help engender a sense of regional community and responsibility through consciousness-raising or concern about the full region.

C. Trade Flows

Because NAFTA is an agreement aimed at liberalizing trade among its members, it is essential to examine next its impacts on trade flows. This can be done by analyzing readily available quantitative data. Here one might employ one of the many existing formal methodologies that

can more conclusively demonstrate and quantify the existence of an independent NAFTA effect, both on trade at the general, economy-wide level and in specific sectors in Canada, Mexico and the United States.

At a minimum, trade flows should be assessed for an individual product, for its major inputs and for the good for which it is a major input. This should be done for trade between the NAFTA members and in their trade with outsiders, beginning in 1991 and using the pre-NAFTA period (1985–90) as a baseline.

The key variables for examination in such an analysis are as follows:

1. ***Value and volume of exports/imports.*** This is the value and volume of exports and imports of each NAFTA country with its other NAFTA partners and with non-NAFTA countries. This includes both goods and services, and serves as the first indicator of how NAFTA's rules and institutions cause economic change.
2. ***Market share.*** This refers to the market share of a product (overall and for imports) that each NAFTA partner's exports represent in each of the other NAFTA countries, and what other countries are being affected by this changing market share. This market-share analysis allows for the control of a number of conditions in the importing economy, as many such conditions should apply equally to imports from NAFTA countries, imports from non-NAFTA countries, and domestic production alike.
3. ***Structure and composition.*** The focus here is how differences over time and across countries are associated with NAFTA liberalization, as specified by the rules of the Agreement and as implemented by its institutions. This considers whether the particular changes in trade flows are consistent with the provisions of NAFTA and the work of its institutions. In addition, it considers the changing structure and sectoral composition in trade over time and across national borders as liberalization substitutes one product for another. In what sectors is the share of the nation's trade increasing and in which is it decreasing?
4. ***Creation and diversion.*** This refers to trade creation and diversion effects with regard to non-NAFTA countries. How does North American liberalization increase trade with some countries, but lessen it with others?

D. Transborder Investment Flows

In important respects, NAFTA was an investment agreement as well as a trade agreement, and transborder flows of foreign direct investment (FDI) are closely associated with trade. In assessing changes among the three North American countries, it is important to focus first on direct investment, and second on portfolio investment.

Direct foreign investment, particularly that of highly integrated transnational corporations (TNCs), brings important capital, management, technology, distribution systems, reputation, markets, and other business assets. Attention should be given to both "greenfield" (new) investment, and acquisitions or expansions, and include both fully-owned investment, joint ventures and North American business alliances. Priority should be placed on changes in stocks, more than on flows of foreign investment, as the latter data incorporate the fullest range of investment alterations.

In assessing these changes, several variables are central:

1. ***Regional concentration of investmen.*** This addresses how post-NAFTA FDI stocks (and secondarily, flows) among the three NAFTA countries, relative to pre-NAFTA periods and non-NAFTA partners, have changed overall, and in particular sectors, for each of the three countries. In all cases, transborder investment should be considered in the context of:

    - domestic investment (including both net domestic investment and the percentage of an industry that is foreign-owned, by firms headquartered and owned in NAFTA and non-NAFTA countries);
    - how investment from NAFTA countries and non-NAFTA countries is concentrating in, as opposed to outside, North America; and
    - the geographic concentration of investment in particular countries and locations within each NAFTA country, including transborder production clusters or transportation corridors.

2. ***Sectoral investment shifts, migration and subsidies.*** This considers whether this investment is expanding most rapidly in relatively polluting or relatively clean sectors. Of particular interest is whether NAFTA-associated FDI constitutes an environmentally costly transfer of industries and plants (including costs for environmental regulatory compliance) from one country or locale in the NAFTA region to another, and how the standards, subsidies, and other relevant government policies compare in those locales. Transfers of investment can take the form of a physical move of an existing plant or an expansion or placement of new investment in one area at the expense of another.

3. ***Technology transfer and diffusion*.** This looks at the degree and speed of the spread of advanced technology from one firm to a related enterprise in the other NAFTA countries. Such a trend is promoted by regional production systems. It increases both technology transfer and diffusion to competing firms in the same industry, to related and non-related firms in the sector, and throughout the economy. Of particular relevance are technologies that improve overall efficiency, and those directed at enhancing environmental quality.

4. ***Intracorporate integration in production.*** This considers whether and how the NAFTA regime is increasing intracorporate trade and affiliated trade between and among the members. Such a process can be expected to encourage integrated production systems that make it more likely that plants operating in all three countries will adopt and follow a common set of standards and practices.

5. ***Corporate concentration.*** This examines how FDI may be encouraging changes in facility size and a trend toward concentration within industrial sectors by creating a smaller number of larger, more capable firms servicing the NAFTA marketplace.

6. ***Foreign portfolio investment*.** This is concerned with how portfolio investment relates to, reinforces, substitutes for, or provides domestically owned firms with the finance for upgrades and expansion in technology and production.

E. Other Economic Conditioning Factors

To demonstrate the presence of a NAFTA connection in trade and transborder investment, it is important to take into account the other macroeconomic and microeconomic conditions that affect trade and FDI flows. Among the most important variables to consider are:

1. ***Domestic macroeconomic forces.*** Relevant domestic macroeconomic forces include aggregate growth, income levels, demand, and consumption in the economy, as distinct from the scale effect of growth and production (and consumption) generated by trade liberalization itself. They also include inflation and interest rates arising from and directly affecting growth, transborder trade and investment. Also relevant are the rate of national savings and investment, and the size of government deficits and debts, all of which affect the demand for foreign capital. Together, these factors influence cyclic changes in price that can affect some sectors.

2. ***Microeconomic changes in each economy.*** Important microeconomic processes include deregulation and privatization. Also significant are the condition of the domestic financial and banking systems, and the availability of credit and insurance. Additional factors include employment levels, the structure of the labor market, and the structure and profitability of firms.

3. ***Major fluctuations from international forces.*** The most important macroeconomic forces in the international domain are exchange rates and the balance of payments deficits and surpluses among the NAFTA countries.

4. ***Changes in weather and climate.*** Unpredictable weather and climatic conditions occurring in the region, including precipitation abnormalities and extremes of temperature, can affect patterns of production, and thus trade and investment.

IV. Linkages to the Environment

The second major function of this framework is to consider how the specific changes associated with NAFTA may be transformed into the environmental pressures, supports and changes that can ultimately determine their environmental impact. This framework identifies four critical linkages through which NAFTA's rules, institutions, trade and investment impact the natural environment, and whose structures and practices will determine the force, timing and direction of those impacts. These four linkages are:

- production, management and technology,
- physical infrastructure,
- social organization, and
- government policy.

A. Production, Management and Technology

The first linkage to the environment is the process, including the technology and management systems, employed by the production unit (usually a firm) that carries out NAFTA-associated

trade and investment, or is otherwise affected by it. The environmental stresses and supports of NAFTA-associated production depend on the following critical variables:

1. ***Inputs.*** This includes raw materials and other inputs to the production process, their sources, and the ecological capital (renewable and non-renewable) they represent.

2. ***Production efficiency.*** This focuses on the efficiency of the process, as well as such additional factors as the location, scale, profitability, and emissions of the producing units.

3. ***Physical technology.*** This considers the physical technology employed in production, including technology that can increase overall efficiency (greater production with lower inputs, emissions and waste), and technology devoted specifically to environmental purposes (such as pollution prevention technologies).

4. ***Management standards.*** These include the dominant strategic management systems for production units, in both their economic and environmental dimensions. Also included are the strategies adopted or devised to respond to NAFTA-affected and other incentives, the presence and use of a high-standards environmental management system or industry-wide environmental code, and the way in which an "environmental culture" permeates management and the firm as a whole. Also relevant is the presence of outside stakeholders in the operation of the environmental management systems.

5. ***Product characteristics and prices.*** These include the relative price and other characteristics of the product, and the environmental emissions and supports flowing directly from this product and its production process. Also important are the performance, use, and ultimate disposal or reuse of the products.

6. ***Sectoral and geographic concentration.*** This includes the number, size and geographic concentration of production units in the sector. NAFTA may reinforce comparative advantage and produce a geographic concentration of production in a few, large, capable firms in environmentally permissive locations.

B. Physical Infrastructure

It is next important to consider the character and environmental impact of the physical infrastructure that supports and sustains the site-specific production units and connects them to their inputs, customers and stakeholders.

Physical infrastructure includes facilities in the public or private sectors. Key components of physical infrastructure are, *inter alia*:

- transportation/transmission infrastructure, including roads, railways, ports, aircraft and airports, electrical transmission corridors, telecommunication grids, pipelines, irrigation canals, locks, dams, trucks, railcars, bridges, grain elevators and warehouses; and
- service infrastructure, including water and sewage plants, the local production and distribution of electricity, telephone and telecommunications networks, and irrigation systems.

Attention should be paid to the overall public and private investment in such infrastructure, the unused capacity of existing systems, and the creation of and need for new systems to handle additional demand.

In examining the environmental impacts of physical infrastructure, the following variables should be considered:

1. ***Existing infrastructure capacity.*** NAFTA may direct trade toward products and services where the existing infrastructure can absorb the new traffic and demands, thereby obviating the need for new investments, new routes, and associated impacts on the environment.

2. ***Correlation of capacity with concentrated activity.*** NAFTA-generated comparative advantage and specialization may concentrate new production activity in geographic locations with an already well-developed transportation/transmission and local environmental service infrastructure. While there will be additional environmental impacts from increased use, incremental additions to a well-developed and regulated network can minimize environmental stress; they may even result in environmental improvement by diverting activity from less efficient, more ecologically stressed regions.

3. ***Choke points.*** NAFTA-generated trade may create choke points that generate local environmental stress where the transportation that carries trade increases or concentrates more rapidly than new transportation/ transmission infrastructure can be constructed to service it.

4. ***Competitive corridors.*** Competition on the part of coalitions of subfederal governments and private sector actors may create new north-south corridors.

5. ***Transcription/transmission scale.*** The scale or volume of NAFTA-generated transportation may increase fuel consumption, emissions, and accidents involving dangerous goods.

6. ***Intermodal shifts.*** The NAFTA-associated intersectoral or "intermodal" shift may produce a net move to more or less environmentally friendly modes. Transporting goods and services involved in trade may be done by sea, rail, road or air, all of which affect the environment in different ways, and trade may concentrate on goods that use one mode rather than the other.

7. ***Distancing effect.*** This refers to moving the "ecological footprint" of production far from the awareness and sense of responsibility of the intermediate and ultimate consumers and their political authorities.

C. Social Organization

The environmental impacts of NAFTA-associated production further depend on the way stakeholders operate collectively in networks of social organizations. Environmental enhancement flows from well-developed networks of social organizations that can add important environmental, cultural and public values to economic and market logic.

Key variables to be considered when assessing the environmental impacts of social organization include the following:

1. ***Civil society groups*.** The way well-organized and influential business, labor, community, consumer, and environmental groups, other cooperatives, and aboriginal communities, act in balanced or inclusive fashion to affirm ecological values is important. Some business associations are engaged in pollution prevention and voluntary environmental standard-setting. Also relevant is the impact of production activities on traditional social units such as the family farm or *ejido*.

2. ***Property rights.*** Regimes that can provide resources for environmental supports, or that respect values other than short-term profitability, foster environmental enhancement.

3. ***Culture*.** The cultural values shared by local and national communities give daily activities significance, render them relatively immune from short-term, rational economic incentives, and may increase environmental awareness and action.

4. ***Migration.*** Migration and associated demographic changes consist broadly of community formation and change, as workers and their families migrate from one location in the NAFTA region to another, to take advantage of employment opportunities or to avoid unemployment. Sudden clustering of populations in ecologically sensitive areas, or ones without adequate environmental infrastructure, can cause environmental stress. Out-migration can lead, over time, to the establishment of community organizations that demand environmental supports. It can, however, also relieve environmental stress.

5. ***Transnational coalitions and community formation.*** The development of trilateral transnational networks of civil society groups, and their involvement in the work of the NAFTA institutions, may enhance environmental awareness and action.

D. Government Policy

A fourth process that influences how NAFTA-associated economic change might affect the environment is government policy. At the national and subfederal levels, government policy plays a major role in forwarding programs that can reinforce, offset or otherwise alter the impact of NAFTA liberalization. Governments also impose and enforce environmental regulations that respond to, or prompt, new developments in production and technology, and that can encourage a move to a high level of general and environmental regulatory convergence in North America. It is important to assess whether NAFTA is sectorally or geographically concentrating production activity in jurisdictions with the highest government regulatory and other policy capacity. Furthermore, is NAFTA facilitating the move to extend such high capacity, through upward regulatory convergence and other forms of environmentally beneficial international cooperation?

The following variables are relevant when considering the role of government policy:

1. ***Government intervention in the market*.** This is the degree of government intervention in the market (or society), including through the use of state-owned enterprises.

2. ***Jurisdiction over environmental policy.*** This refers to the division of responsibility for environmental policy and the degree of cooperation between federal and subfederal governments, notably, the degree of centralization within the three central systems. Decentralization can compound problems of upward convergence, but it can also generate competitive innovation that is environmentally beneficial.

3. ***Balance between government branches*.** Relevant also is the balance within governments among the executive, legislative and judicial branches. In general, the coordinated or convergent involvement of all three branches in environmental policy is likely to promote environmental enhancement. Pertinent within the executive branch is the balance and relationship among environment, trade, foreign, finance and industrial-sector ministries, and the role of central government in coordinating them. This would include the involvement of the head of state or government. An equal and integrated role for environment ministries and agencies and the active involvement of leaders will almost certainly lead to environmental enhancement.

4. ***Strength of market-oriented government policies*.** This includes the strength of government polices to ensure freely functioning markets, rather than monopolistic or oligopolistic concentrations, which are asymmetrical in their policies of access, information and accountability, and thus tend to be environmentally harmful. It further includes government policies and interventions intended to increase efficiency and compensate for market failure, in order to affect the macroeconomic and microeconomic forces discussed above.

5. ***Effects of specific government policies on the environment.*** These potentially powerful instruments to improve environmental quality include:

    - procurement practices,
    - environmental management systems used by state-owned enterprises,
    - financial instruments such as taxes, credits, subsidies, and user fees,
    - government research and development, and technical assistance,
    - regulation, environmental assessment, and intellectual property rights,
    - direct environmental regulation of producers and consumers, and
    - conservation programs.

6. ***Environmental surveillance and enforcement.*** High capacity and performance of governments in environmental surveillance and enforcement reduces environmental stress.

7. ***Trilateral cooperation at various governmental levels outside NAFTA institutions*.** Increased trilateral cooperation at the federal and subfederal level on environmental issues enhances the quality of the environment.

V. Indicators of Environmental Impacts Stemming from NAFTA

The third major component of this framework provides indicators to assess how NAFTA-associated processes generate environmental pressures and supports that affect the four major components of the ambient environment: air, water, land and living things (biota). Environmental pressures tend to increase the stress on the environment by providing a further load on its absorptive capacity, while environmental supports respond to these pressures, or to independent changes in the state of the environment.

The impact of pressures, combined with that of supports, will vary according to the existing state of the natural environment in the geographic area affected. In some cases, small net increases in pressures over supports can have a major catalytic and potentially irreversible effect on the ambient environment. In other cases, a small amount of environment-enhancing intervention can generate large gains. Of particular interest are high impact locales—places where environmental pressures concentrate to overwhelm the available supports.

Of ultimate interest is the cumulative impact of such pressures and supports on air, water, land, and biota, and on the aggregate indicators that help move towards an integrated understanding of overall ecosystem conditions and dynamics.

These four components—air, water, land, and biota—and the overall state of the environment can be assessed at both a general or sector/issue level. The key indicators identified here are those which are nationally or internationally recognized in scientific and policy realms for their importance. They are, further, of particular relevance to the distinctive biophysical characteristics and ecosystems of the North American region and to the environmental issues at the forefront of public and policy interest in NAFTA. They should be considered in general analyses and by all sector/issue studies. Not all of these indicators will be relevant for every sector/issue study. However, this set can act as a starting point or checklist for identifying environmental effects, while more detailed sector/issue specific indicators are being developed and analyzed.

The following list concentrates on those indicators where reliable cross-national data is currently available, so that application of this framework might proceed immediately. Within each of the four domains of the ambient media, an effort has been made to include indicators relating to the major environmental pressures, states, and supports or responses.

A. Air Indicators

Most generally, air, the atmospheric environment, includes local and regional air quality, pollution levels, and broader processes such as stratospheric ozone depletion and climate change. Specific indicators for examination include the following:

1. ***Acid precipitation*.** The acidification of lakes and rivers diminishes their ability to support aquatic life. Acid precipitation and dry deposition, caused principally by emissions and concentration of sulfur oxides (SO_x), primarily sulfur dioxide (SO_2), damage ecosystems as well as buildings and highways, cause forest damage, accelerate leaching of metals from rocks and soils and decrease agricultural outputs. Effects on humans include eye and

respiratory system irritation. Children and those with respiratory disease are particularly susceptible to harm.

2. ***Ozone (O_3)concentration.*** Ground-level ozone, the primary component of smog, is an important air pollution problem shared by all three countries. High concentrations can lead to inflammation of the respiratory tract, respiratory illness in children, reduced pulmonary function, a decreased capacity for work and exercise, and even death. Individuals with heart or lung disease are more susceptible to all of these symptoms. It also damages crops and ornamental plants. Principal ozone precursors (in combinative reactions catalyzed by sunlight) are the following:

   - **Nitrogen oxides (NO_x).** These ground-level ozone precursors also contribute to acid precipitation, dry deposition and photochemical smog. They are chiefly produced by high-compression internal combustion engines, as well as by some industrial furnaces, and by lightening.

   - **Volatile organic compounds (VOCs).** VOCs are produced by fossil fuel combustion, as well as by incinerators, gasoline and petrochemical vapors, paints and solvents, and various industrial processes.

3. ***Particulate matter (PM).*** This is a broad category of air pollutants that includes a range of small solids or liquids that vary in size and chemical composition. Some particles are acidic "acid aerosols." There are particle categories that include toxic substances, such as heavy metals, polycyclic aromatic hydrocarbons, as well as numerous other organic compounds. Anthropogenic sources include industrial activities, incineration, agriculture, construction, and mobile sources. PM is commonly divided by size fraction:

   - **PM_{10}** consists of fine particles 10 micrometers or less in diameter. These inhalable particles have been implicated in chronic lung disease since 1979. They are also associated with pulmonary and heart disease and are major contributors to urban haze. PM_{10} can reside in the atmosphere for hours or days before settling to earth.

   - **$PM_{2.5}$** refers to the smallest and most dangerous particulate matter, those particles measuring 2.5 micrometers or less—an estimated 60 percent of PM_{10} particles. They may include a wide range of toxic metals and chemicals as well as sulfates and nitrates. $PM_{2.5}$ have been implicated in cardiorespiratory illnesses, premature death due to respiratory disease, reduced pulmonary function, and bronchitis.

   - **Elemental metallic particulates.** These can include toxic heavy metals, such as mercury (Hg) and lead (Pb). In biological systems, these are persistent and bioaccumulative, causing cancer, birth defects, organ damage, and disorders of the nervous system. Mercury, especially, can volatilize and be reinjected into the atmosphere by a variety of mechanisms, moving hundreds or thousands of kilometers from its original sources.

4. ***Persistent organic pollutants (POPs).*** These are organic molecules, often of extremely high toxicity, characterized by low water and high fat solubility. This causes them to

bioaccumulate to high levels as they move up the food chain. Many POPs are pesticides—such as mirex, toxaphene, DDT, and chlordane—and others include polychlorinated biphenyls (PCBs), dioxins and furans, and various other byproducts of industrial processes. Some POPs are now known to function as endocrine disrupters and interfere with the functioning of hormones. Others may be responsible for declining sperm counts and rising levels of birth abnormalities among certain human populations and affected animal species.

5. ***Carbon monoxide (CO) emissions and concentrations.*** This compound impedes the absorption of oxygen into the bloodstream, causing headaches, nausea, fatigue, and impairment of judgment. In extreme concentrations, it is lethal. Produced by mobile sources and fossil fuel combustion, in terms of volume, it is the single most important component of air pollution. CO oxidizes readily in the atmosphere to form carbon dioxide, which is involved in the cycle of global warming.

6. ***Carbon dioxide (CO_2).*** The fourth most abundant gas in the earth's atmosphere, carbon dioxide poses no direct threats to human health. However, the gas is implicated in global warming through its contribution to the greenhouse effect, and its output from combustion activities in developed and developing countries is probably exacerbating this phenomenon.

B. Water Indicators

Analysis parameters for water include its quality and quantity in uses ranging from drinking to irrigation, the condition of inland, coastal, and groundwater areas, and how much of it is subjected to effluent discharges of such compounds as pesticides and fertilizers. Water is both an essential part of ecosystem and human health, and a basic resource for most economic activities and processes. Elements for consideration include the following:

1. ***Quality of drinking water.*** This considers the presence of such harmful contaminants as VOCs, pesticides, PCBs, semi-volatile synthetic organic contaminants, antimony, arsenic, barium, beryllium, cadmium, chromium, cyanide, fluoride, mercury, nickel, nitrate, nitrite, and selenium. These contaminants are known to cause a wide range of health problems.

2. ***Freshwater use (by source/sector).*** Overuse of water resources can result in low river flows, water shortages, salinization of groundwater in coastal areas, loss of wetlands, desertification and declining sustainability for agriculture.

3. ***Lead concentration.*** Concentrations over threshold standards have adverse effects on human health.

4. ***Copper concentration.*** High concentrations kill fish and cause brain damage in higher animals.

5. ***Surface water pollutants.*** These include suspended solids, fecal coliform bacteria, and the total content of phosphorus, nitrates, dissolved oxygen (related to biological oxygen demand—BOD). Fecal coliform bacterial level is an indicator of the possible presence of pathogens. Nitrates and phosphorous are the primary substances that cause eutrophication of lakes and rivers. Reduced levels of dissolved oxygen affects the ability of a body of water to

assimilate wastewater and to support fish and aquatic plant life. Extreme conditions, such as at the mouth of the Mississippi River, result in "dead" zones incapable of supporting life.

6. ***Fish capture*.** Conservation of fish stocks requires a balance between biological productivity and harvesting rates. Lower fish captures can indicate water quality problems.

7. ***Sewage treatment connection rates*.** Discharge of untreated, used water is one of the prime causes of water contamination. This element of physical infrastructure is an indicator of efforts, or lack thereof, to decrease pollution loads.

C. Land Indicators

Parameters related to land include soil quality and patterns of land use, including agriculture, forest cover, and natural and protected areas. Here attention should focus on soil erosion, soil conservation and other tillage methods, soil runoff (of substances such as nitrates, fertilizer and pesticide buildup from over-application), the overuse of marginal land from expanded agricultural production, land left fallow, and land conversion. Some specific indicators are as follows:

1. ***Intensity of pesticide use for agriculture*.** This component of production, technology and management is important because pesticide use adds persistent organic chemicals to ecosystems. Pesticides accumulate in soils and biota and are passed on to humans through food and water consumption. Residues leach into surface water and groundwater.

2. ***Nitrogen from fertilizers and livestock*.** Overabundance of nitrogen may exceed the assimilation capacities of soils. The surplus may leak into groundwater or run-off of surface waters, contributing to eutrophication.

3. ***Area of forested land.*** Forests have many functions, including provision of timber and other wood-derived products, recreational benefits, and ecosystem services. They provide habitat in support of biodiversity and act as carbon sinks.

4. ***Intensity of forest use*.** Clearcutting and unsustainable harvest rates cause loss of habitat and affect wildlife survival.

5. ***Waste generation*.** This is best considered by type: household/municipal, hazardous, industrial, and nuclear. At its most benign, waste disposal consumes land. If improperly managed, especially with hazardous substances, disposal can have significant impacts on human health and the environment.

6. ***Recycling rate.*** Recycling reduces the need for waste disposal.

D. Biodiversity Indicators

Biota refers to overall biodiversity, i.e., all forms of living organisms, including animals, plants and microorganisms. Industrial activities and intensive agriculture and forestry can lead to the pollution or erosion of soils, which in turn adversely affects flora and fauna. The loss and

fragmentation of forests and wetlands (either through nonsustainable harvesting or conversion to other land uses) also results in the loss of biodiversity. Animals and plants, essential parts of the environment, also serve as economic resources for human activity. Indicators should reflect both aspects. Areas of consideration include the following:

1. ***Number of threatened/extinct species*.** Many ecological processes depend on wildlife, including native mammals, birds, fish, reptiles, amphibians, plants and, especially, insects.

2. ***Wetlands*.** Wetlands store and allow the slow release of large quantities of water, provide protection from erosion, provide habitat for waterfowl and fish, and offer recreational opportunities.

3. ***Protected areas*.** Healthy natural habitat of adequate size is necessary for species' survival.

E. Aggregate Indicators

An aggregate indicator or index consists of two or more individual indicators. All indicators reflect pressures, responses or changes in the state of an ambient environmental medium. They also often reflect, at least indirectly, the linkage processes that lie behind them. However, it is useful to include indicators that address change in more than one environmental medium, or that integrate more directly the interactions among economic, social and environmental processes.

Integrative indicators are particularly difficult to develop, given the complexity of the theoretical calculations involved and the need for more experimental results to substantiate them. Nonetheless, development work on several indicators has shown promise. The following aggregate indices and integrative indicators are among those. They avoid many of the pitfalls of index construction by aggregating only those indicators that are measured in the same units.

1. ***Climate change*.** A commonly-used pressure index relevant for climate change is total greenhouse gas emissions. The index is the weighted summation of five gases that contribute to global warming: carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NO_x), chlorofluorocarbons (CFCs) and halons. The theoretical foundation for the weights used in the index is strong, since the weights are based on the Global Warming Potential (GWP) of each gas. One tonne of CO_2, for instance, has a GWP of 1, while the other gases are known to be larger contributors to global warming, per unit weight. For example, over a 100-year period, the GWP of methane is 11 times greater than that of carbon dioxide, while the GWP for CFC-12 is 7,100 times greater. Multiplying the annual emissions of each gas by its GWP transforms the emissions into CO_2 equivalents (Ceq), and then these amounts are summed across the gases to produce the index.

2. ***Ozone depletion*.** Stratospheric ozone shields humans and other organisms from harmful ultraviolet (UV) rays. Excessive exposure to UV rays causes skin cancer, cataracts and immunosuppressive diseases in humans and animals. It also causes degradation of materials such as rubber, wood and plastics, and slows plant growth. The damage to the ozone layer caused by CFCs, halons and other ozone-depleting gases, depends on their residence time in the atmosphere and the rapidity with which they contribute to the decomposition of ozone. These two factors determine the ozone depletion potential (ODP) of ozone-depleting gases.

An ozone depletion pressure index can be formed by multiplying the emissions of CFCs and halons individually times their ODP and then summing the products. Since generation—or the atmospheric liberation (in the case of CFCs)—of these substances is assumed to be correlated with emissions, and since production data are usually more readily available than emissions data, it is convenient to use production rather than emissions data in the index. Indicator weights deriving from the ODP have scientific backing, and therefore overcome the subjectivity inherent in the weights found in many types of environmental indices.

3. ***Acidification.*** The three main acid gases incorporated in an acidification index are sulfur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). The contribution of each gas to the acidification of atmospheric water vapor or surface lakes and rivers is weighted by its acidic potential and expressed in acidification equivalents.

4. ***Eutrophication*.** Two major contributors to the eutrophication of water bodies are nitrates and phosphates. This index aggregates emissions of nitrogen and phosphorous, using a weighting scheme that accounts for their potential eutrophication effect.

5. ***Cost of environmental remediation*.** The cost of environmental remediation refers to the cost of cleaning up polluted or degraded environments and reducing pollution generated by human activity. Examples of remediation include building sewage treatment plants, cleaning up contaminated soil, installing pollution control devices in industrial plants, and replanting forests. This index is particularly attractive because it combines measures of the economy (including production, management and technology, physical infrastructure, social organization and government policy) and the environment.

6. ***"Ecological footprint."*** Although extremely complex to apply, this index is useful, as it produces results that are easy to visualize. It estimates the total land area needed to produce all of the resources consumed by the population of a specific geographic unit (e.g., a city or country) and to assimilate the wastes discharged by that population.

7. ***Energy intensity.*** Greater efficiency in energy production and use reduces environmental stresses. This indicator also combines measures of the economy and the environment, and does so from a preventative rather than remedial perspective.

8. ***Human health costs of environmental pollution.*** Polluted air, water and land result in quantifiable hospital and health care costs from the illnesses they cause, which can be calculated and used as an indicator.

9. ***Energy mix*** (by source: coal, oil, gas, nuclear, hydro, other). This component of production is important because higher reliance on fossil fuels in the energy mix is associated with more severe local and regional air quality problems and with greater production of greenhouse gas emissions.

10. ***Biological integrity.*** This index can reflect the cumulative effect on natural ecosystems of a wide variety of chemical and physical stressors on natural ecosystems, and the extent to which the ecosystem supports healthy biological communities.

VI. Conclusion

This framework is offered to individuals, institutions and governments to assist in understanding the linkages between environmental and trade policies. Such an understanding will assist the Commission for Environmental Cooperation, and its constituents in North America, to protect and enhance the environment in the face of expanding economic activity and build synergies between the two policy areas. The CEC encourages individuals and organizations to apply the framework to priority sectors and issues in North America. As past experience suggests and future application will confirm, the use of this framework is a dynamic process and further development will be required as the base of our empirical evidence expands and the analytic linkages become clearer and more refined. The CEC is committed to continuing to work both empirically and analytically on issues that link trade and environment—the ultimate goal being a better North American environment, a mission all North Americans share.

Part II: User's Guide to the Final Analytic Framework

Developing and applying an analytic framework to assess NAFTA's environmental effects is a complex and challenging task. Throughout the process, difficult but informed choices must be made to pursue particular methodological paths, emphasize specific variables and relationships, and focus on priority uses—taking into account the distinctive features of NAFTA, the North American economy and its environment. Above all, such a framework must reflect the fact that NAFTA is only one cause of economic and environmental change in North America.

This background document details how the present analytic framework constructed to assess NAFTA's environmental effects has dealt with these complexities. It has three central purposes:

- to identify and explain the analytical and methodological choices made in constructing the Framework;
- to provide basic background information about the characteristics of the North American economy and environment that were relevant in shaping the Framework; and
- to report the empirical results of preliminary applications of the Framework.

In designing this Analytic Framework, five considerations have been fundamental.

1. The first is the focus on NAFTA in particular, rather than on trade or trade liberalization in general, taking into account the comprehensive and innovative character of the NAFTA "regime." This "regime" is construed as including the principles, norms, rules, and decision-making procedures specified in the NAFTA agreements, together with the institutions they created. The NAFTA trade agreement itself covers a broad set of subjects. It deals not only with trade but also with investment and several other aspects of economic life.

   NAFTA contains changes to the principles and rules governing North American commerce and related activities. In addition, to apply, interpret and extend the Agreement, it also created or catalyzed the subsequent emergence of about fifty trilateral intergovernmental institutions. NAFTA was accompanied by two "parallel" or "side" agreements—one for the environment and one for labor. These are the North American Agreement on Environmental Cooperation (NAAEC), and the North American Agreement on Labor Cooperation (NAALC). Each agreement established a new institution: the Commission for Environmental Cooperation (CEC) and the Commission for Labor Cooperation (CLC), respectively. Together these institutions represent a new network of North American oversight.

   In assessing NAFTA's environmental effects, it is important to include the specific new principles and rules brought about by NAFTA, the way they have been implemented and altered in practice by the NAFTA institutions, and their relationships with the rules and institutions of parallel environmental and labor agreements.

2. This framework distinguishes clearly between environmental processes that are associated with NAFTA and those that are not. It begins with a comprehensive and precise conception of what "NAFTA" is, both to avoid falsely attributing to the trade agreement changes whose causes lie elsewhere, and also to capture the range of effects that NAFTA may have on the North American environment. Therefore, in designing the framework, care was taken to

focus on major relationships and consider factors not related to NAFTA that cause environmental change.

3. It is also important to consider both the direct and indirect effects of NAFTA, and the many processes through which NAFTA may ultimately affect the environment. In order to do this the framework is constructed and outlined in a linear fashion. It begins with the context within which NAFTA operates in relation to the entire region or to a particular sector or issue of interest. It next considers NAFTA's rules and institutions and their trade and transborder investment effects. It then addresses "linkages to the environment"—formed by processes of production, physical infrastructure, social organization and government policy. These processes might be affected by the NAFTA-induced changes in trade and investment and in turn may shape how such change affects the ambient environment. Finally, the framework examines the resulting environmental pressures, supports and changes to air, water, land and living things.

4. This framework is flexible in its application. In outlining and applying it in a linear way, three factors must thus be kept in mind. First, NAFTA's rules and institutions may have a direct impact on the four processes of production, physical infrastructure, social organization and governmental policy, without these processes first affecting or being transmuted by altered trade and investment patterns. Second, the analytical linkages between variables within the framework are complex and multidimensional, and contain many feedback loops—notably the way in which changes in the ambient environment themselves affect NAFTA's rules and institutions and the trade and investment associated with it. Third, this is a flexible framework that can be applied by starting at any point of key interest, such as environmental change, and tracing the relationships to other variables associated with it.

5. While focusing on the North America experience, this framework forms part of a larger effort to identify and improve the analysis surrounding the environmental effects of trade liberalization agreements. It builds on and contributes to existing studies within the governments and research communities within and beyond North America. Several recently published studies provide guidance on addressing components of NAFTA's effects, notably its effects on trade (DFAIT 1997; US TR 1997a, 1997b; US ITC 1997a, 1997b). Now, however, more than five years after NAFTA formally came into force, there is still no comprehensive analysis of effects that NAFTA has had on the environment in North America.

I. Methodological Issues

This Analytic Framework has been designed to meet the needs of multiple users, from those seeking to understand NAFTA's effects on the ecology of North America as a whole, through to those concerned about NAFTA's relationship to a particular environmental issue or problem in one local area or sector within one country of North America. The framework has thus been fashioned so that it may be applied at many different levels of analysis, from the most macro to the very specific, including ultimately the activities of individual communities or firms. At present, it may be applied both generally and to specific issues or sectors. In all cases it examines in turn the NAFTA regime and associated trade and investment flows, and traces four major

processes through which activity generated or affected by NAFTA's rules and institutions affects the region's environment.

A. Level of Application in the Analysis

At present, the framework may be applied most readily to individual sectors of the North American economy, or to particular environmental issues within or across such sectors. In order to encourage a close look at pressing concerns, and particularly those that contribute to a larger and ultimately comprehensive understanding of the dynamics of the region as a whole, it is useful to develop criteria by which to select sectors and issues for priority application.

Selection of Sectors

To maximize overall understanding of NAFTA's environmental effects, the following five criteria may serve as a guide for the selection of sectors:

1. The sector must relate directly to major environmental media and natural resources.
2. The sector has been the subject of changes in the economic rules set by NAFTA.
3. The sector has experienced changes in trade during the post-NAFTA period.
4. The sector has involved new direct foreign investment among NAFTA parties since 1994.
5. The sector is one where one might expect, *a priori*, that there would be important effects attributable to NAFTA.

During Phase II of the NAFTA Environmental Effects project, several sectors of the North American economy were considered in light of these criteria. On the basis of this, the agriculture and energy sectors were chosen as those warranting priority attention.

In the case of agriculture, the large variety of major crops and livestock grown and traded within the NAFTA region produce a broad range of environmental issues. Such priority environmental issues include: possible effects on the Canadian dairy, poultry, grain, and oilseed industries from NAFTA-enhanced trade and expanded US production and competition; Mexican imports of US corn and exports of fruits and vegetables; and use of water, fertilizers and pesticides. The agriculture sector is a central concern for public policy and the subject of much intergovernmental and trilateral institutional activity throughout the NAFTA area. Some of the major public policy issues raised by the agricultural sector in North America relate to the implications of recent reforms in Mexican agricultural law, the increasing incidence of agricultural non-tariff barriers throughout the NAFTA region, and the dismantling of Canada's supply-managed milk, dairy, egg and poultry industries. Much of the relevant agricultural trade and related investment was directly or indirectly affected by NAFTA.

Energy also emerged from an application of these criteria as a leading sector for priority attention. From its generation, transportation, and transmission to the efficiency of its ultimate use, energy has a comprehensive impact on the North American environment. Its effects are pervasive, as it is a critical input for all economic sectors and individual households. NAFTA has made several specific changes to the rules for trade and investment in the energy sector, and governments of the NAFTA Parties have concurrently been in the process of major policy changes at their national levels. These NAFTA-associated changes in trade and investment,

combined with such other forces as the advent of the "open grid," are rapidly bringing a fully integrated North American marketplace into being.

Selection of Issues

Within and across these broad economic sectors, this framework allows analysis of specific issues of environmental consequence. The five criteria for identifying specific issues for analysis are as follows:

1. The issue must relate directly to major environmental media and natural resources.
2. The issue is significant from an environmental perspective.
3. The issue bears some important relationship to the integration of the North American economy through NAFTA rule changes, government policy changes, institutional changes, investment changes or direct trade impacts.
4. This analysis will contribute to an understanding of other issues of importance in North America.
5. This analysis will contribute to tracing linkages among the elements affected by NAFTA and the agreement's impact on the environment.

In Phase II of the project, these selection criteria were applied within the broader economic sectors identified previously. Their application yielded three specific issues for analysis: maize in Mexico, feedlot production of cattle in the United States and Canada, and electricity in North America. This provided a balanced array of issues involving all three countries (electricity), two countries (cattle), and one country (maize).

One study examined the impacts of imports and attendant domestic liberalization in the Mexican white corn sector and its ultimate effects on the environment. An important contribution had seemed likely from a careful identification of ecologically beneficial effects of NAFTA-induced changes in the maize economy. In part, this was because NAFTA rule changes have altered trade and investment flows in the agricultural industry, with many of the most significant changes taking place in the US-Mexican agricultural trading relationship. At the same time, Mexico has reformed its agricultural and subsidy policy relating to maize. NAFTA-induced policy changes and rule changes could generate both positive and negative environmental effects over a broad range of variables affecting, in particular, land, water and biodiversity. Maize was thus a rich issue from an environmental perspective. Through the exploration of the complex environmental variables related to its production and use and an examination of the NAFTA rule changes and NAFTA-induced policy changes surrounding this issue, it was one that promised to serve as a useful model to clarify some of the linkages between trade liberalization and processes (including technological adaptation and social organization) that affect the environment.

Such a clear NAFTA connection was also evident in the case of concentrated cattle feedlots. In an effort to take advantage of the new trading environment, firms are rationalizing cattle production in North America. Environmental impacts and regulatory changes have occurred as a result of more concentrated feedlotting of cattle in particular areas of the United States and Canada. This study thus examined the environmental impacts of the altered structures of this industry, and its relationship with cross-border trade in livestock and feed grains. The concentrated feedlot production of both cattle and hogs has been an emerging problem in Canada

as well as the United States, as Canadian meat producers have sought to take advantage of a more favorable post-NAFTA regulatory structure. In Mexico, imports of US feed grains are posing challenges for producers of more traditional grains, notably maize. This made the study especially important—not only for the livestock sector, but also as it relates to the feed grain and food grain needs of North America.

The issue study on electricity in North America examined the environmental implications of the increasing potential for trade in electricity, fuels and related technologies. Electricity sectors in North America are undergoing a process of significant structural change. Traditional industry structures are being exposed to new types of competition, which are being introduced largely as a result of the gradual easing of restrictions on who can generate, transmit, distribute and sell electricity. There is also increasing interest in the potential for cross-border trade in electricity—both between Canada and the United States, and between the United States and Mexico. In Canada and the United States, the trend is toward deregulating the access to transmission for sub-federal public utilities. This important public policy issue is generating a great deal of interest in North America. As well, if impacts could be ascertained in the Canadian-US relationship, they might emerge in the Mexican-US relationship. Here trade was likely to increase at a much faster rate as the Mexican electricity sector underwent similar forms of liberalization. A Canadian-US analysis could point to policy implications that might be expected in the Mexican-US relationship and even in the emerging Canadian-Mexican relationship.

B. Modeling

At the different levels of analysis, this framework can be applied through various qualitative (even anecdotal) and quantitative methods, including partial and general equilibrium economic modeling and ecological modeling. In all cases, these methods—employed alone or in combination—should integrate the major variables that appear in the framework, including legal, economic, institutional, social, political and ecological factors.

Relevant Modeling Efforts Currently Available

As a foundation for applying and developing this framework through quantitative modeling-based approaches, a brief review of recent relevant work in the field of trade and the environment may be useful.

By definition, a model is a simplification designed to represent a system; if it is computable, it is supported with statistical data (see Kmenta 1971). An economic model attempts to represent the stocks and flows of an economy to determine and forecast demand, supply, consumption, production, and the like.[1] A trade model extends this analysis to include cross-border flows of imports, exports and, where possible, mobile factors such as capital and labor. Such determinations and forecasts are subject to numerous errors, ranging from the statistical and theoretical to the empirical (see Hayo 1998; Hendry 1997). Broadly speaking, empirical economic trade models are divided into computable general equilibrium (CGE) models and

[1] Hendry (1997) describes the success of econometric forecasts as a function of four factors: (1) There are regularities to be captured. (2) These regularities are informative about the future. (3) The proposed method captures these regularities. (4) Excluded are nonregularities that swamp the regularities.

partial equilibrium (PE) models.[2] In CGE models, supply and demand for all goods are treated simultaneously in all sectors and countries under analysis. In PE models, by contrast, the focus is on a single industry or sector, so that connections with other sectors are left out in the interest of more detailed analysis.

At the same time that economic trade models have been developed, considerable effort has occurred in the last decade at modeling the environmental impacts of economic activity. Much of this work revolves around environmental indicators (see Farrell and Hart 1998). Canada was among the first to develop an environmental indicators program (in 1989), and published plans for sustainability based on these indicators in 1993. Similar efforts are now underway in other countries, based especially on various versions of the OECD "pressure-state-response" framework. Efforts have also been made to incorporate environmental values in the System of National Accounts (SNA), using "green accounting" or "satellite accounts" (UN 1993; Repetto 1992). The newer Index of Sustainable Economic Welfare (ISEW) adjusts standard economic accounting measures, such as income and consumption, for pollution-reduction expenditures and environmental degradation (Stockhammer et al. 1997).

Notwithstanding the progress in this area, there is no consensus over appropriate indicators for the environment comparable to those long used in economics. More importantly, this lack of consensus has hampered theoretical and empirical efforts to marry economic and environmental indicators in a synthetic model incorporating both effects. The simplest of these exercises involves linking trade data on export growth, for example, to indicators of "pollution intensity" in sector-by-sector studies (see Ferrantino and Linkins 1996; Runge et al. 1997). This work, and other hybrid trade-environment models discussed below, relies heavily on the pollution intensity data set developed for US manufacturing by Hettige and colleagues, the Industrial Pollution Projection System (IPPS), at the World Bank (Hettige et al. 1995: Lucas et al. 1992).[3] Pollution is measured in terms of toxic pollutants in water, air, and land; bioaccumulative toxic metals in air, soil and water; air pollutants such as SO_x, NO_x, and CO, volatile organic compounds (VOC) and particulates; biological oxygen demand (BOD); and total suspended solids (TSS).

The other main data set on environmental impacts used in economic analysis of environment-trade linkages is that produced by the Global Environment Monitoring System (GEMS), which has been recording SO_2 concentrations in major urban areas in 44 countries since the early 1970s. This monitoring system was initiated by the World Health Organization (WHO), and has formed the basis of work by Grossman and Kreuger (1992) and various studies by Taylor and coauthors, to be discussed below.

Recent work in the development of economy-wide CGE models, led in part by researchers at the OECD Development Centre, has begun to show promise in linking trade to these environmental impacts. Illustrative are empirical assessments of trade-environment linkages by Beghin and various coauthors (Beghin et al. 1995; Beghin and Potier 1997; Beghin et al. 1997). These efforts

[2] This discussion is based in part on the thoughtful review comments of Michael J. Ferrantino (1998) and his cited reference to Francois and Reinert (1997) and US ITC (1997b).

[3] The IPPS draws from the US EPA Toxics Release Inventory for 1987 to calculate total releases for 320 toxic substances, weighted by the risks estimated by the EPA Human Health and Ecotoxicity Database. Particularly useful is the World Bank web site: <http://www.worldbank.org/nipr/polmod.htm>.

derive from the OECD Development Centre's prototype CGE model, applied to a variety of specific countries and sectors.[4] Beghin et al.(1995) adapted the OECD model to Mexico, creating the Trade and Environment Equilibrium Analysis (TEQUILA) model, which has the important technical advantage of deriving pollution emissions from intermediate as well as final consumption. This contrasts with input-output (Leontief) models, in which the only way to reduce emissions is to reduce final demand (see Dessus et al. 1994). The TEQUILA model links consumption to pollution using the thirteen pollutant parameters noted above, including toxic pollutants, bioaccumulative toxic materials, air pollutants, particulates, and water pollution.

Three dynamic features of the TEQUILA model bear emphasis. These include growth in labor supply and capital stock, productivity growth, and the flexibility with which new capital is substituted for old.[5] The model is calibrated using a detailed social accounting matrix for Mexico, with eight labor categories and 20 households, divided evenly between urban and rural. Trade is modeled assuming goods are differentiated with respect to region of origin and destination, and distortions are expressed as *ad valorum* tariffs for 22 agricultural sectors and 14 processing sectors.

Results from the TEQUILA model indicate that economic integration in Mexico, measured against a 1990–2010 base trend, will result in less pollution-intensive activity, but also in increases in the scale of economic activity. Increases in total emissions will require targeted environmental interventions to be mitigated. Results are presented for a sequence of three reforms: environmental tax reform, trade liberalization, and a combination of trade and environmental reforms. In effect, the model allows separate judgments about the environmental effects of trade liberalization without accompanying environmental reforms, the environmental impacts of taxes designed to compel companies to deal with the environmental repercussions of their activities, and the joint effect of liberalization accompanied by such environmental taxes.

In the cases of environmental tax reform or trade liberalization taken alone, Mexican output falls moderately, but trade liberalization alone induces expanding sectors (e.g., rice, horticulture, coffee and honey) to become more pollution intensive. Only when trade reforms are combined with environmental reforms is expanded GDP accompanied by emissions decreases in almost all sectors (Beghin et al. 1997, pp. 124–130). It is this combination, or balance, that has been at the center of several proposed trade/environment policy reforms (see Beghin and Potier 1997; Runge et al. 1994). Broadly speaking, the value of the TEQUILA model is that it allows examination of complicated effects in various sectors and subsectors due to economy-wide changes in environmental and/or trade policy. In this respect, it offers a very promising tool in assessing potential issues and trouble spots as changes occur under NAFTA.[6]

[4] Beghin and Potier (1997) also present a review of evidence on the impacts of trade liberalization using the scale, composition and technique effects first developed by Grossman and Krueger (1992).

[5] More technically, TEQUILA is a recursive dynamic model, so that each period is solved as a static equilibrium problem given an allocation of savings and expenditure on current consumption. It has 92 sectors. Labor supply is given exogenously, while capital stock evolves with investment activity. Productivity is given by attributing efficiency factors to capital, labor by occupation category, and energy. Capital stock and its vintage are influenced by the time path of total and sectoral allocation (Beghin et al. 1995, p. 781; Beghin et al. 1997, p. 119).

[6] For example, it shows surprising increases in toxic emissions in the production of honey after trade liberalization, even with environmental reforms (Beghin et al. 1997, p. 129).

A similarly detailed modeling effort, led by Hertel and colleagues, is the Global Trade Analysis Project (GTAP). Here a CGE model is used for sectoral evaluations of trade liberalization in agriculture, forestry, fisheries, mining, processed food and beverages, textiles, and wood products (see Hertel, ed. 1997).[7] While this model has been used to examine some environmental issues, such as global climate change, it has been less specifically targeted to these impacts than the TEQUILA model. However, it has proven useful in showing the relative differences in effects from CGE models and partial equilibrium models (Tsigus et al. 1997). This work also allows comparison of GTAP estimates with partial equilibrium studies based on such models as the Static World Policy Simulation (SWOPSIM) used by the US Department of Agriculture to estimate trade impacts for 22 food and agricultural commodities and 36 countries/regions of the world (Roningen 1986). The GTAP work on climate change concludes that partial equilibrium models that incorporate processing sectors produce satisfactory results in estimating prices and quantities, although they understate effects occurring through labor and capital markets (Tsigus et al. 1997, p. 302). Other applications of the GTAP modeling framework to forecasting include Anderson et al. (1996).

In a 1999 evaluation of environmental standards harmonization in the Western Hemisphere, Tsigus et al. (1999) used the GTAP model, as expanded by Perroni and Wigle (1997), to examine 24 regions and 37 aggregates.[8] Due to insufficient international data, pollution emission estimates for soil erosion, pesticide runoff and livestock waste were drawn from US sources. Soil erosion estimates were based on US experience with the Conservation Reserve Program (CRP) (Osborne 1995). Estimates of pesticide runoff were based on the environmental impact quotient (EIQ) developed by Kovach et al. (1992). Amounts of livestock pollution were extrapolated from nitrogen emission rates based on US Soil Conservation Service estimates (SCS 1992). Manufacturing pollution was based on the World Bank data set of Hettige et al. (1995). Like the work of Beghin et al. (1997), the study by Tsigus et al. (1999) explored the impacts of trade liberalization with and without accompanying environmental taxes harmonized across the Western Hemisphere. They considered both absolute (US) levels of environmental policy harmonization and relative (i.e., differentiated) harmonization, in which environmental taxes were less stringently applied in Latin American countries. Their results indicate that environmental policy intervention, together with trade liberalization, is most beneficial when applied at less-than-US levels in countries such as Mexico, Argentina and Brazil, but is clearly preferable to no environmental intervention and trade liberalization. As Tsigus et al. (1999, 20) noted: “relative environmental policy harmonization does not greatly diminish gains from regional trade policy liberalization and it appears to be preferable to absolute harmonization.”

Several other economy-wide modeling efforts bear mention. They include work undertaken to estimate impacts of multilateral trade liberalization by or in cooperation with the World Trade Organization (WTO) Secretariat, such as work quantifying the likely impacts of the Uruguay Round of multilateral trade negotiations. Harrison et al. (1997) used a CGE model of 24 regions and 22 commodity groups to assess the impact of the Uruguay Round, and compared these

[7] Documentation of the model and its uses by other modeling groups in Australia (ABARE), the Netherlands, and at MIT and the Environmental Policy Research Institute (EPPI), is available at its Purdue University web site: <www.Purdue.agecon.edu/GTAP>.

[8] An earlier effort by these authors at CGE modeling of trade-environment effects suggested that trade impacts on environmental quality were negligible (Perroni and Wigle 1994).

estimates with other modeling efforts using a base year of 1992. They found that the world as a whole gains from $96 billion to $171 billion annually, depending on model assumptions, with gains concentrated in the developed countries. This was compared to earlier work by a team at the GATT/WTO Secretariat, which found global gains of $510 billion in 1990 dollars, projected forward to 2005 (Francois et al. 1994). When Francois et al. (1995) also used 1992 as a base year, their estimate was $193 billion, within one standard deviation of the Harrison et al. (1997) counterpart model. Neither of these efforts explicitly linked these results to environmental impacts or indicators.

Robinson developed a CGE model of trade liberalization that explicitly accounted for pollution externalities, prior to the development of the "pollution intensity" data noted above. One such effort developed a multisector, economy-wide CGE model in which pollution and pollution abatement were explicitly included in a social welfare function, and were joined in a nonlinear programming model (Robinson 1990). Similar models have also been applied to US-Mexican migration and agricultural policies under NAFTA (Robinson et al. 1993).

Another CGE model, developed at the University of Michigan, the Brown-Deardorff-Stern CGE Model of World Production and Trade, has been applied to NAFTA and its potential enlargement to include Chile, Argentina, Colombia and Brazil (Brown et al. 1995). Although no explicit environmental effects were modeled, the Brown-Deardorff-Stern work is capable of such enlargement. The model has already been enlarged to include a services sector (Brown et al. 1996).

In an application to Morocco, Diao and Roe (1998) used an intertemporal CGE model to consider the impact of trade liberalization on water prices and the potential for water trading schemes. Essentially, they showed that by expanding trade in intensive water-using crops such as fruits and vegetables, the price of water is driven up, putting pressure on policies which subsidize and distort water markets. This argument is likely to have considerable relevance to Mexico.

Although it is often argued that models have difficulty capturing investment and technology changes, recent efforts suggest that at least some aspects of these changes can be assessed. Work ongoing at the World Bank, for example, has sought to capture the environmental implications of shifting investment and technology under trade liberalization (Cruz et al. 1997; Munasinghe et al. 1996). Using the CGE model to analyze the effects of public infrastructure investments on Mexican national income, Feltenstein and Ha (1999) showed that such investments have rapidly decreasing benefits.

Apart from CGE models, several authors have used theoretical simulations to explore various trade-environment linkages. Abrego et al. (1998) explored the strategic incentives that drive countries to link environmental issues to trade liberalization (see Hauer and Runge 1998). The main result was that a joint trade-environment negotiation provides leverage to developing countries that they lack in a trade-only negotiation.

Papers by Taylor and various coauthors (Copeland and Taylor 1994, 1995, 1997, 1999; Brander and Taylor 1997a, 1997b) have explored the decomposition of trade liberalization and its effects on the environment, following the work of Grossman and Kreuger (1992), in which the

composition of national output due to trade reforms, and its pollution intensity, was estimated (see Runge 1995). These studies rely on environmental data from the World Health Organization's Global Environmental Monitoring System (GEMS), noted above. The most well-developed empirical application is Antweiler et al. (1998), in which a simple model highlights the interaction of factor endowments and income differences in determining the pattern of trade.

In particular, using multi-country panel data, Antweiler et al. (1998) distinguished scalar increases in economic activity (the scale effect) of trade liberalization resulting from cleaner environmental technologies consequent to increases in income (the technique effect). The authors found that a one percent increase in the scale of economic activity increased pollution concentrations by 0.25 to 0.5 percent, but the accompanying increase in income drove these same concentrations down by more than one percent. By analyzing the sensitivity of country characteristics in determining the impacts of trade openness, they showed trade liberalization to have a relatively small impact on pollution concentrations. Using data from 40 developed and developing countries, they confirmed the earlier, more restricted findings of Grossman and Kreuger that trade liberalization induces positive changes in production techniques that ultimately offset negative environmental scale effects. Finally, they found that pollution induced by economic growth is directly tied to the sources of this growth: income gains due to trade or (neutral) technological progress lower pollution, while those due to capital accumulation raise it.

Data Needs and Limitations

There can be little doubt that the accumulation of better data will assist in advancing these and other modeling efforts. The paucity of data is greatest involving the environmental impacts of trade. The definition of environmental "damage functions," and the metric by which such damage should be measured, are both underdeveloped, as are the data to support them. As noted above, the two most well-developed efforts are the data sets on manufacturing pollution developed by Hettige et al. (1995) at the World Bank, and the Global Environmental Monitoring Systems (GEMS) data set on urban pollution developed by the World Health Organization. Other environmental indicators, such as those employed by Tsigus et al. (1999), use US data to project effects for the entire Western Hemisphere. The pollution intensity of estimates of the World Bank are also primarily based on US EPA data.

A very substantial need exists to replicate these estimates for the United States elsewhere, notably in developing countries. In addition, some of the other efforts at environmental indicator development noted above (e.g., Stockhammer et al. 1997) might usefully be linked to trade models. It is especially critical to examine the ways in which trade is supposed to drive environmental changes, since these mechanisms are still very imperfectly understood. Work by Taylor and colleagues (e.g., Antweiler et al. 1998) has focused especially on disentangling the complex paths by which such effects occur. As observations on pollution and its abatement are developed into data sets for other parts of the world, it will be important to extend these observations over time, so that trends and patterns related to economic expansion and business cycles can be better understood. In the final analysis, both cross-section (multiple country and region) and time-series (multi-year) data will be needed.

Foreign Direct Investment and Technology Transfers

Foreign Direct Investment (FDI) and the international transfer of technology are notoriously difficult to model (Deardorff 1999). There exists little clear consensus over the behavioral foundations driving either type of activity, The theory translated into modeling equations or parameters, when attempted, is largely ad hoc. This is an especially glaring problem from the perspective of developing countries, where both FDI and technology transfer are among the most important factors conditioning economic growth and development. As noted above, work at the World Bank has begun to try to capture these effects and their environmental implications (Cruz et al. 1997; Munasinghe et al. 1996).

Research by Antweiler et al. (1998) revealed the critical importance of these issues for trade-environment analysis. For example, disaggregating scale and technique effects is a precondition for determining the relative environmental impact of income transfers versus FDI. As Antweiler et al. (1998, n. 1) note: “income transfers across countries raise national income but not output, whereas foreign direct investment raises output more than national income.” If the technique effect is primarily a function of income expansion and the scale effect is primarily a function of output, separate estimates of these effects will be needed to distinguish the consequences of FDI from income transfers.

This analysis indicates that, at present, existing economy-wide and ecology-wide quantitative models show promise. However, they have thus far been generally less useful than more sectorally and qualitatively focused approaches in relating economic change to environmental impacts. Forging such a relationship is a central concern of this framework. While some helpful work is available correlating changes in trade and investment by sector with the pollution intensities of those sectors, such analyses still do not incorporate important differences in production and technology among the three NAFTA countries or other intervening processes such as those identified in this framework. Efforts to realize the potential of quantitative models should focus on generating the required data from all NAFTA countries, linking trade with environmental indicators, and identifying how the different processes unleashed by NAFTA-associated trade and investment liberalization affect the environment in distinct ways. The existing, limited state of such modeling efforts should not, however, deter or delay efforts to build new models or applications relying on other quantitative or qualitative techniques.

II. Empirical Background

These methodological considerations have helped shape the development of a framework that examines in turn the rules and institutions that form the NAFTA regime, the trade and transborder effects associated with them amidst other economic forces, and their impact on linking processes and the environment. This section of the paper examines the various components of the framework, outlining in detail the variables and hypothesized relationships included, explaining their selection, and reporting relevant recent evidence as a guide to further application and development.

A. The Broader Context

The environmental impact of an activity will often be determined by a range of forces, many unconnected to NAFTA. It is thus necessary to identify and take into account throughout the analysis, environmental, economic, social, geographic and political factors that have an important effect on a particular issue or sector. By identifying the relevant context at the start, this Framework guards against attributing to NAFTA environmental changes that are not empirically associated with it, and assists in isolating the identity, direction and force of particular processes that are.

It is necessary to first consider the full range of environmental dimensions of an activity selected for analysis. This will confirm the environmental relevance of the subject and clarify the difference between the environmental effects of the activity itself and any deriving from NAFTA. These environmental dimensions are considered, as subsequently in the Framework itself, through a pressure-state-response model. Such a model describes pressures exerted on the environment, the latter's responses to them, supports arising from them and the resulting state of the ambient environment.

Environmental pressures include the wastes, byproducts and emissions of economic activities, as products and services are produced and consumed and as natural resources (particularly nonrenewable ones) are transformed in production. Environmental supports include the direct provision of environmental goods and services, such as the creation of natural protected areas, restoration of wilderness areas, and waste management practices, or indirect processes, such as the reduction of stress on marginal lands, or activities resulting from lower subsidies for heavily polluting fuels. The state of the ambient environment includes the condition of the major media: air, water, land and biota.

Environmental change in these media can have an important autonomous effect on economic activity, whether NAFTA-related or not. Factors such as weather patterns, including temperature and rainfall, affect production, distribution and trade. The dynamic complexity of ecological systems as natural phenomena mean that they respond only partially to human-created change, and to the economic, social and political forces that a trade agreement creates. Yet they can exert a powerful independent effect on such economic processes as the levels of crop production, or the generation of electricity.

Second, the economic character of an issue will often be largely or even wholly determined by a range of forces unaffected by NAFTA, particularly in relatively large, closed economies such as the United States. Thus, environmental impacts in an issue or a sector may be based on long-established patterns of activity in domestic macroeconomic factors, international macroeconomic factors, and domestic microeconomic factors.

Domestic macroeconomic forces are the key economic trends that affect an issue or a sector. As suggested in the discussion of economic modeling above, such forces include growth and production, demand and consumption, population and income, and prices of a product or service, as these change over time and in relation to other goods and services in the economy. Also relevant are inflation rates, interest rates, and credit as affected by government policy and savings rates, and fiscal policy, including deficits and debt.

International macroeconomic factors may also be relevant. These include exchange rates that determine the relative prices of domestic and international goods, and the current and capital account balances that can lead to macroeconomic adjustment.

Domestic microeconomic factors may also be relevant. These include systems for banking and credit, the size and concentration of firms in an industry and sector, and labor market dynamics.

In exploring the operation and impact of these processes, it is important to start by recalling the differences in the overall size and structure of the United States, Canadian and Mexican economies. In overall economic size, the US$8 trillion GNP of the United States is about ten times larger than that of Canada and 20 times larger than that of Mexico. The three countries thus rank, respectively, as the world's first, eighth and fifteenth largest economies. Another difference is in average income levels, where the average per capita income in the United States and Canada substantially exceed that in Mexico.

There are further important differences in the structure of the economies. Canada is a highly open economy, where exports of goods and services account for almost 38 percent of GDP—about three times the level in the United States. Canada is also heavily reliant on inward foreign direct investment, having a larger share of its business sector owned by foreigners, especially from the United States, than any other major advanced country.

In addition, economic and ecological changes can be influenced by the social context in which they unfold and by the social institutions that sustain them. The individuals that produce and consume do so not only in response to rational market and price incentives, but also as social beings equipped with a wide variety of preferences, embedded in family and community networks grounded in cultural values.

One important social factor is the quantity, quality and mobility of the labor force, and its responsiveness to incentives (such as language and local community) other than purely market ones. Of potential relevance is the organization of the workforce into labor unions, and the role that they and others play in pressing for high health, safety and environmental standards, and other social improvements.

A related factor is migration, as workers and their families move, temporarily or permanently, within a country, or to other countries within the region, in search of employment opportunities and family reunification. Migration, domestically and internationally, can be both a cause and a result of environmental change.

A further social factor is the presence and strength of cooperatives, community groups and civil organizations, notably environmental, consumer and other nongovernmental organizations. Their impact depends also on their resources and the property and other rights they possess. Of particular relevance are the associations and networks through which industry engages in environmental standardization on a sector- or economy-wide basis. These associations may involve a broad range of stakeholders.

A final factor is culture, a dimension of relevance to sectors that are, for historical and other reasons, highly valued by a population as an integral part of national life. For example, some Canadians may retain an attachment to publicly produced and distributed electric power or non-trade water, and Mexicans to domestic maize production and consumption for historical reasons not fully reducible to current economic calculations.

These social and cultural differences are expressed within political systems that also exhibit considerable diversity. Politically, while all three countries have federal and democratic systems, the traditionally centralized and state-dominated Mexican polity contrasts with stronger subfederal units in Canada and the United States. This is particularly notable in policy areas related to the environment, where an estimated 70 percent of constitutional responsibility rests with the provinces in Canada. It is also apparent in national regulatory and standards-setting systems. Mexico's reliance on central government regulation, for instance, contrasts with Canada, where provinces and five major multistakeholder standards-setting bodies have an important role. It also contrasts with the United States, where states and many hundreds of private standard-setting associations play a major part.

Finally, change can be influenced by the variety of geographic features—such as geology, climate, hydrology and demography—throughout North America, and within each of the three diverse NAFTA countries. Territorially, both Canada and the United States are large transcontinental countries bordering on three oceans, with a varied climate that includes Arctic regions. Mexico includes important tropical areas. Environmentally-relevant geographic conditions vary within each country and can influence the nature, location and extent of economic activity. Demographically, the 275 million consumers in the United States provide a much larger market than the 85 million in Mexico and the 30 million in Canada. Mexico's population is also, on average, younger than that of the United States or Canada.

III. The NAFTA Connection

After the context has been set, the framework identifies the content of the "NAFTA regime," as a referent for isolating the economic and other changes that flow from it. This section identifies ways in which NAFTA is connected to these other changes, and the key components of the rules and institutions that comprise the "NAFTA regime."

The NAFTA regime exerts its effects in several ways. One is the impact it may have had, through anticipatory, strategic adjustment on the part of actors, before it came into force on 1 January 1994. NAFTA had already acquired an identity and impact on the consciousness of some of the North American public well before the agreements themselves were negotiated and took formal effect. This began in the United States and Mexico as early as 1990 and extended to Canada after it joined the NAFTA negotiations in February 1991. The intergovernmental negotiations and political debates over NAFTA had a further impact through the adjustment of national policies. This was based in large part on domestic considerations but was also inspired by the prospect of NAFTA and by the wish to take maximum advantage of the opportunities it offered.

NAFTA further affects the environment in both direct and indirect ways. NAFTA's rules and institutions have equipped North American governments—and, in some cases, citizens—with instruments for improving the environment directly. However, much of NAFTA's impact will arise indirectly, as its rules and institutions first alter trade and transborder investment flows and interact with the production, infrastructural, social and governmental processes that create pressures on the environment or supports for it.

In some cases, NAFTA confirms and consolidates the impact of changes already underway in the private sector, in the national economies of the parties, and in other trade liberalization arenas. In these cases NAFTA exerts effects as it codifies existing or emerging practices, representing a governmental and intergovernmental response to, reflection of, and legitimization of economic and corporate activity already underway. By putting an authoritative, intergovernmental "seal of approval" on emerging North American trends through NAFTA, this very act stabilizes and reinforces them. Such a NAFTA confirmation is important, as the ongoing process of trade liberalization, economic integration and community formation underway in North America prior to NAFTA was not an inevitable trend with a certain course. The vigor of the NAFTA debate both before and after the passage of the agreement shows that something very important was, and is, at stake.

A. NAFTA Rule Changes

NAFTA's rules are those specified in the agreement itself and its tariff annexes. At the heart of NAFTA are the rules dealing explicitly with a specific product or sector (including both goods and services). Of key interest are rules that are different from, or that change, those of the Canada-United States Free Trade Agreement, the General Agreement on Tariffs and Trade (GATT) or other trade liberalization agreements in which the three countries participate. Instances where NAFTA confirms existing rules are also relevant.

In general, the rules contained in the NAFTA agreements can be taken as a fixed baseline for the purposes of analysis. Evidence suggests that the three governments have generally complied with NAFTA to implement intended trade liberalization in accordance with the phase-out schedules specified (Weintraub 1997, US TR 1997a).

Specific Rules

The specific rules of greatest relevance are the following:

1. ***Tariff reductions and other border measures.*** This refers to reductions in and other border measures on a specific product. These include tariffs, quotas, quantitative restrictions, and rules of origin. NAFTA-specified reductions can be assessed according to:

   • the base-level tariff among the three countries prior to NAFTA;
   • the degree and timing of liberalization already scheduled to take place according to other trade agreements and unilateral national action;
   • the particular NAFTA tariff phase-out schedule; and
   • the tariffs that NAFTA parties maintain and face with non-NAFTA countries.

2. ***Changes affecting goods/services once imported.*** These include changes in product standards and government procurement rules. For example, NAFTA's procurement rules require Mexico's *Comisión Federal de Electricidad* (CFE) to consider bids from suppliers in the United States and Canada in addition to Mexico.

3. ***Inputs.*** This refers to tariff reductions and other border measures affecting major inputs to relevant products and goods. This includes domestic measures with a similar effect. Electricity trade, for example, may be affected by tariff changes on coal or electrical generating equipment.

4. ***Substitute products.*** This refers to tariff reductions and other border measures affecting "like" or substitute products. Rule changes affecting a particular product or sector must be considered relative to changes regarding related products and sectors among NAFTA countries and with their other trading partners. Full account must be taken of the possibility of substitutions encouraged by the differential reduction of tariffs and other trade barriers across individual items and sectors.

The case of maize in Mexico demonstrates that rule changes affecting a particular product or sector must be considered relative to changes in related products and sectors (such as yellow corn in the United States or grain in Mexico). The differential pace and degree of reduction and elimination of tariffs and other trade barriers under NAFTA can have major impacts on production and consumption substitution in ways that are not optimal for economic efficiency or environmental enhancement.

General Rules/Crosscutting Disciplines

NAFTA also includes general rules which, while not explicitly applying to a product (such as generation equipment) or sector (such as electricity or energy), discipline the means or processes by which products and services (and their inputs) in all sectors across the economy are produced, sold or purchased. They include the NAFTA rules that govern behavior laterally on an economy-wide basis (e.g., government procurement, risk assessment methodologies) and temporally through anticipatory or deterrent effects.

Such general rules include the following:

5. ***Norms for particular processes.*** Such norms include the Article 1114 disciplines on investment; risk assessment, sanitary and phytosanitary standards; health and safety standards; procurement policies; and investment guarantees.

6. ***Preambular principles and stated objectives.*** NAFTA's stated objectives include the promotion of sustainable development and strengthening of environmental regulation and enforcement.

Also relevant are rules introduced subsequent to the signing of the agreements, notably:

7. ***National implementing legislation.*** This refers to legislation required in the three countries for NAFTA and its related agreements to take force, including agreements subsequent to NAFTA itself, such as the Canadian intergovernmental agreement governing provincial participation.

8. ***Accelerated tariff reduction.*** These are those rules generated by the NAFTA institutions or those reached intergovernmentally subsequent to the Agreement coming into force, and the cumulative overall reduction of tariffs and trade and investment barriers, including future specified liberalization, that parties can anticipate and adjust to in advance. This overall liberalization and opening of markets creates new competitive pressures that differentially affect specific sectors and products, depending on the height of previous trade barriers and the underlying level of North American competitiveness.

B. NAFTA's Institutions

NAFTA institutions are the 26 trilateral intergovernmental bodies created directly by NAFTA and its related agreements, and the similar number catalyzed or inspired by them since 1 January 1994 (Weintraub 1997, CEC 1996b, CEC 1997b). These institutions are designed to implement, interpret, and extend the agreements and their specific principles, norms and rules. The actual operation of these institutions independently affects the application and result of NAFTA rules, even when the latter come with precise mandates, and targets and timetables for action. The cases of trucking access to Mexico for US and Canadian carriers and trilaterally-mandated work on automotive emissions show the difference between rules on paper and results in practice.

There are a number of core institutions that can be included in this examination, as identified below. In all cases, it is important to consider the relationship of these institutions with national regulatory and government authorities, which retain significant capacity and whose intergovernmental cooperation outside NAFTA institutions has substantial effects.

The NAFTA institutions of greatest relevance to the environment are:

- the Council of the Free Trade Commission (FTC);
- the Council of the Commission for Environmental Cooperation (CEC);

- institutions created by NAFTA with mandatory environmental responsibilities, particularly if they have a target and timetable related to a particular product or sector or process, an example being the Automotive Standards Council on emissions;
- institutions created by NAFTA whose subject matter has an inherent environmental relevance, such as those dealing with agriculture; and
- NAFTA's dispute settlement, avoidance and surveillance mechanisms, notably NAFTA Chapters 11, 19, 20, and most broadly NAAEC's Articles 14, 15, 23 and 24. Here the focus should be on their operation in cases with clear environmental dimensions. For example, of the 11 cases initiated from 1 January 1994 to 20 August 1999 under the Chapter 11 process on investment in NAFTA, eight have concerned environmental regulations or had a clear environmental relevance.

To assess the impact of these institutions, it is important to focus first on their development as trilateral entities and their specified purposes, programs, resources and decision-making procedures. Thus far, the evidence suggests that most of the NAFTA institutions with specific environmental responsibilities or relevance have moved into operation, with activity beginning in 1996 (CEC 1997b).

It is also useful to examine how each performs functions that deepen the NAFTA regime, balance separate national interests with trade and environment communities, and promote sustainable development.

Within relevant institutions, the following functions should be examined:

1. ***Meeting mandatory responsibilities.*** There have been concrete environmental achievements in some cases, notably the transportation of dangerous goods and pesticides. Yet performance varies. In some areas, such as automotive emissions, slow progress has been made in meeting mandatory targets and timetables (CEC 1997b).

2. ***Acting upon discretionary environmental mandates.*** The institutions may act on the discretionary, environmentally-related mandates set forth in NAFTA or its related agreements such as those where the Parties "may" rather than "shall" act on environmental issues, such as off-road vehicle emissions. In the latter case, there has been no action during NAFTA's first five years (CEC 1997b).

3. ***Extending to other relevant subjects.*** The institutions include within the trilateral process additional subjects and issue areas beyond those specified in the initial agreements.

4. ***Generating new institutions.*** The institutions may perform a role in catalyzing other bodies or processes as part of, or outside, the NAFTA structure of institutions. From 1994 to 1997 there was a notable institutional proliferation, with the original 26 institutions doubling to about 50 and the new additions being at least as environmentally-oriented as the originals (CEC 1997b). NAFTA's institutions also include other regular trilateral processes that have emerged, such as those at the ministerial level for Transportation, Health and Agriculture.

5. ***Fostering communication.*** This can be done through an open exchange of information and learning. During NAFTA's first five years, there has been considerable cooperation, openness and trust emerging on a trilateral basis (CEC 1997b).

6. ***Building capacity.*** This is done by sharing resources of a financial, material and intellectual nature.

7. ***Discouraging unilateral action.*** Norms developed in institutions can lead to a reluctance to use national restrictive measures and can allow problems to be collectively resolved at an early stage. This would include how institutions act to constrain unilateral use of discretionary national regulatory and compliance measures.

8. ***Fostering high levels of environmental convergence.*** The institutions may foster a high level of regional convergence in environmental regulations. Here NAFTA, and the CEC in particular, has helped foster a high level convergence through a process of mutual adjustment among the three NAFTA members. In some key sectors such as automotive products, however, such convergence has taken place outside of the NAFTA institutions or process (Kirton 1998b).

9. ***Participating multilaterally.*** The institutions may strengthen cooperation among the three North American countries as they participate in broader multilateral forums. They may thus be extending the geographic relevance of NAFTA's work through its effect on outsiders (including use as a model), and by developing complementary North American positions and consultations in outside forums. For example, NAFTA's agricultural bodies have begun to consider common North American interests in relation to the outside world, and the 1996 Canada-Chile Free Trade Agreement was created very closely and consciously according to the NAFTA model.

10. ***Contributing to community building and identity.*** The institutions may help engender a sense of regional community and responsibility through consciousness-raising or concern about the full region. On one important dimension of community building there has been limited movement to integrate and balance trade and environment values in the interaction between the NAFTA institutions primarily responsible for each, and in the operation of the work of the NAFTA institutions as a whole.

In considering the long-term economic and environmental impact of NAFTA, it is vital to view these rules and institutions as making up a dynamic, expanding regime. Most basically, they will evolve, as tariff reductions take effect in stages and as institutions come to full operation. Moreover, the rules and institutions will change, as those charged with applying them acquire experience, or react to numerous economic forces and outside pressures. Most broadly, the rules and institutions will change in response to NAFTA-related and external environmental effects, as particular problems or successes engender new rules and concentrate institutional activity in certain areas rather than others. Through the work of its institutions, NAFTA can have an important environmental impact.

Looking ahead, it is useful to explore how the performance of such functions deepens the NAFTA regime by producing additional liberalization, and broadens the process to include other issues. Of ultimate interest is the impact of the NAFTA institutions, in behavioral process and substantive outcome, in integrating and balancing the interests of the three countries and the trade and environment communities, and creating or privileging regional interests and sustainable development objectives. In all cases, it is important to consider the relationship of these institutions with national regulatory and government authorities, which retain significant capacity and whose intergovernmental cooperation outside NAFTA institutions has substantial effects.

It is also useful to examine how the NAFTA institutions encourage consultation and regulatory designs that exploit opportunities for harmonization (as in animal health, meat and plant inspection, grading standards, mercury emissions). At present there appear to be opportunities for major gains in the convergence of national and introduction of region-wide standards in several areas, such as electricity. Even where the NAFTA institutions currently provide the capacity for such convergence, as in agriculture, there is relatively little environmentally enhancing activity in evidence.

C. Trade Flows

Because NAFTA is an agreement aimed at liberalizing trade among its members, it is essential to examine the impacts of its rules and institutions on trade flows. This can be done by analyzing readily available quantitative data. Here one might employ one of the many existing formal methodologies that can more conclusively demonstrate and quantify the existence of an independent NAFTA effect on trade at the general, economy-wide level and in specific sectors in Canada, Mexico and the United States. There are also a number of studies employing different methodologies that conclusively demonstrate such an effect.

The majority of these studies suggest that the economic effects of NAFTA are broadly positive or neutral on major indicators such as trade growth, GDP, income, and employment (US TR 1997a). A few allege specific negative effects on such selected indicators as income equality and trade diversion (Council on Hemispheric Affairs 1997, and Economic Policy Institute 1997). Several studies also detail beneficial-to-neutral trade effects in specific sectors (US TR 1997b). For example, in the case of feed grains, the NAFTA provisions replacing Mexico's protection with a tariff-rate quota system have led to increased Mexican imports of the liberalized products or close substitutes from the United States (Runge et al. 1997). In the case of energy, NAFTA reductions in the tariff on coal have had the same effect (CEC 1999).

The sectoral composition of trade can affect the environment in both positive and negative ways. There is some evidence to suggest that the sectoral composition of post-NAFTA trade, and the dynamic changes in the share of such trade among sectors, is not having a negative effect on environmental quality (CEC 1999).

It is possible to move beyond aggregate statistics to firm-level behavior and use more detailed "process tracing" methodologies that connect the NAFTA regime to the trade that results from it. Through specialized interviews with corporate officials and other stakeholders, public data and other methods (such as NAFTA certificates of origin on goods or the qualification of firms for

NAFTA adjustment assistance in the United States), it would be possible to explore how NAFTA relates to creating or reducing new trade flows among firms and what are the distinctive production characteristics of this NAFTA-associated trade.

Identifying NAFTA's trade effects at a firm level is also a manageable task because North American trade, both overall and in most sectors in all three countries, is heavily concentrated in a few large companies. For example, 63 percent of all US exports globally are made by transnational corporations (TNCs), many of them very large firms. A full 50 percent of Canada's exports come from only 50 firms, many of them foreign-controlled (CEC 1996a, 123). Regular survey research could assist in assessing their trade and investment performance and intentions, the importance of NAFTA in their corporate strategies, and the production characteristics of their NAFTA-related trade and investment.

At a minimum, trade flows should be assessed for an individual product, for its major inputs and for the good for which it is a major input. This should be done for trade between the NAFTA members and in their trade with outsiders, beginning in 1991 and using the pre-NAFTA period (1985–90) as a baseline.

The key variables for examination in such an analysis are as follows:

1. ***Value and volume of exports/imports.*** This is the value and volume of exports and imports of each NAFTA country with its other NAFTA partners and with non-NAFTA countries. This includes both goods and services, and serves as the first indicator of how NAFTA's rules and institutions cause economic change.

2. ***Market share.*** This refers to the market share of a product (overall and for imports) that each NAFTA partner's exports represent in each of the other NAFTA countries, and what other countries are being affected by this changing market share. This market-share analysis allows for the control of a number of conditions in the importing economy, as many such conditions should apply equally to imports from NAFTA countries, imports from non-NAFTA countries, and domestic production alike. It leads to an analysis of how differences over time and across countries are associated with NAFTA liberalization as specified in its rules and implemented by its institutions.

3. ***Structure and composition.*** This considers the changing structure and sectoral or intrasectoral composition of trade that liberalization has brought about on a cross-country basis over time as product substitution and specialization take effect.

4. ***Creation and diversion.*** This refers to trade creation and diversion effects with regard to non-NAFTA countries.

Analyses of the trade impact of NAFTA during the first few years of its formal operation suggested that the NAFTA regime was having a substantial, trade-creating effect among all three of the two-way trading relationships governed by it. It further suggested that such NAFTA-expanded trade was not having a negative environmental effect, concentrating trade in sectors that were pollution intensive. Production grew from maquiladoras in locations under environmental stress, but with greater attention focused on the effects of that stress.

It is important to update this analysis, in particular to take account of the trends that have developed as a result of several factors. These factors include:

- the accomplishment of much of NAFTA's five-year tariff phase-outs and the two rounds of accelerated tariff reduction that have come into effect;
- Mexico's recovery from its 1995 economic recession;
- the Asian-turned-global financial crisis and emerging market downturn from 1997–99; and
- the sustained growth in the US economy during the late 1990s.

At present, an examination of recent trade flows suggests that NAFTA continues to have an effect in stimulating and sustaining increased trade among the three member countries (International Monetary Fund 1998).

US-Canadian Trade

From 1991 to 1998, US trade (both exports and imports) with Canada almost doubled, from US$178.9 billion to US$332.2 billion. During the three years of NAFTA anticipation from 1991 to 1993, when the 1989 bilateral Canada-United States Free Trade Agreement was also exerting its initial pull, US trade with Canada rose 19.5 percent, to US$213.8 billion. During the following three years, when NAFTA first took formal effect, it rose 36.7 percent, to US$292 billion (in 1996). During the subsequent two years of the mature NAFTA, it rose again by 13.7 percent, to US$332.2 (in 1998). In all cases the annual increases exceeded the growth in GNP of the United States and Canada. These increases are all the more remarkable, given the very high level of pre-existing US-Canadian trade as the decade began. Indeed, that bilateral relationship was and is the largest two-way bilateral trading relationship in the world.

US-Mexican Trade

The impact of NAFTA was expected to be far more evident in the US-Mexican trade relationship, given the lower levels of that trade, the smaller size of the Mexican economy and the absence of any prior major free trade arrangements (apart from the maquiladora program). The record has met these expectations. Between 1991 and 1998, two-way US trade with Mexico (starting from a base one-third that of US trade with Canada) more than doubled, from US$65.1 billion (in 1991) to US$160.0 billion. During the three years of NAFTA anticipation, the trade rose 26.6 percent. During the initial three years of NAFTA's formal operation, it jumped a striking 58.9 percent. In the following two years, it increased again by 22.2 percent. In all three periods, the increase was greater than that experienced in the US-Canadian relationship.

Canadian-Mexican Trade

The Canada-Mexico relationship was expected to experience the largest autonomous, NAFTA-propelled increase, if only because of the very small size of the pre-existing trade and other commercial connections between these two geographically and linguistically distant partners. The record bears out this expectation. During the decade, Canada's two-way trade with Mexico more than doubled, rising 136 percent from US$2.5 billion in 1991 to US$5.9 billion in 1998. In

the three ante-NAFTA years, it rose 32 percent (to US$3.3 billion in 1993). This was a much higher rate than that of the other two NAFTA bilateral trade relationships. During NAFTA's initial formal operation, it increased a striking 55 percent (to US$5.1 billion in 1996), or almost as much as US-Mexican trade during the period. In the subsequent two years, it grew again by 15.7 percent (to US$5.9 billion in 1998).

The fact that the US-Mexican trade relationship experienced large percentage increases, both overall and in the years after NAFTA took formal effect, points to the influence of two additional factors. The first is the sustained demand in the US economy. The second is the advantage of proximity in an era of just-in-time inventory. Also relevant is the fact that the transshipment through the United States of Canadian and Mexican goods means that Canada-Mexico trade is underreported and that of NAFTA's other two relationships overreported. In the case of Canadian exports to Mexico, the totals are much higher than those reported by conventional measurement practices. A further sign of the autonomous, trade creating, and potentially trade diverting effect of NAFTA can be seen in the pattern of cumulative concentration of each member's trade with its NAFTA partners.

Two-way US trade with Canada moved from 19.2 percent of US global trade in 1991 to 20.4 percent in 1998 (temporarily peaking at 20.5 percent in 1995), with both exports and imports contributing to the concentration. Two-way US trade with Mexico increased from 7 to 9.8 percent over the period 1991–98, with both exports—but especially imports (which rose from 6.3 percent to 10.4 percent)—contributing.

Table 1: United States trade with NAFTA partners
(millions of US$)

	Canada		Mexico		Total Trade	
Year	Exports	Imports	Exports	Imports	Canada	Mexico
1991	85,146	93,736	33,276	31,866	178,882	65,142
1992	90,156	101,292	40,598	95,886	191448	136,484
1993	100,191	113,617	41,635	40,745	213,808	82,380
1994	114,255	131,956	50,840	50,356	246,211	101,196
1995	126,024	148,304	46,312	62,756	274,328	109,068
1996	132,584	159,746	56,761	74,111	292,330	130,872
1997	150,124	171,440	71,378	87,167	321,564	158,545
1998	154,155	178,049	61,668	98411	332,204	160,079
(share of world trade)						
1991	0.202	0.184	0.079	0.063	0.192	0.070
1992	0.202	0.183	0.091	0.174	0.191	0.136
1993	0.215	0.189	0.089	0.068	0.201	0.077
1994	0.223	0.191	0.099	0.073	0.205	0.084
1995	0.234	0.192	0.079	0.081	0.203	0.081
1996	0.213	0.195	0.091	0.091	0.203	0.091
1997	0.218	0.191	0.104	0.097	0.203	0.100
1998	0.226	0.188	0.090	0.104	0.204	0.098

Notes: Total Trade is equal to Imports + Exports

Source: International Monetary Fund, Direction of Trade Statistics Yearbook, 1998; International Monetary Fund, Direction of Trade Statistics, Quarterly, June 1999.

Table 1 indicates that in the period after NAFTA took effect, total US trade with Canada increased by approximately 85 percent, representing an increase of 1.2 percent of total US trade. In the same period US trade with Mexico increased by approximately 145 percent, representing an increase of 2.8 percent of total US trade.

The two-way trade of the much smaller and much more open Canadian economy experienced a greater concentration. From 1991 to 1998 its trade with the United States rose from 69.2 percent to 77.6 percent of its total, as exports to the United States rose from 75.8 percent to 86.5 percent and imports from the United States rose from 62.3 percent to 68.3 percent of the Canadian global total. Canada's trade share with Mexico rose from 1.0–1.4 percent of the Canadian total.

Table 2: Canadian trade with NAFTA partners
(millions of US$)

	United States		**Mexico**		**Total Trade**	
Year	Exports	Imports	Exports	Imports	United States	Mexico
1991	95,574	75,025	386	2,131	170,599	2,517
1992	103,860	79,294	613	2,207	183,154	2,820
1993	114,448	87,759	599	2,665	202,207	3,264
1994	133,112	99,628	715	3,126	232,740	3,841
1995	152,896	108,988	786	3,774	261,884	4,560
1996	164,761	114,626	855	4,281	279,387	5,136
1997	177,317	131,948	916	4,968	309,265	5,884
1998	182,802	136,816	858	5,079	319,618	5,937
(share of world trade)						
1991	0.758	0.623	0.003	0.018	0.692	0.010
1992	0.778	0.635	0.005	0.018	0.709	0.011
1993	0.813	0.650	0.004	0.020	0.734	0.012
1994	0.825	0.658	0.004	0.021	0.744	0.012
1995	0.804	0.667	0.004	0.023	0.741	0.013
1996	0.823	0.674	0.004	0.025	0.755	0.014
1997	0.832	0.675	0.004	0.025	0.757	0.014
1998	0.865	0.683	0.004	0.025	0.776	0.014

Notes: Total Trade is equal to Imports + Exports

Source: International Monetary Fund, Direction of Trade Statistics Yearbook, 1998; International Monetary Fund, Direction of Trade Statistics, Quarterly, June 1999.

Table 2 shows the increase in Canadian trade with the NAFTA partners since the signing of the Agreement. Trade with the United States increased by approximately 87 percent, representing an increase in the US market share of 8.4 percent. Trade with Mexico increased by 136 percent, which translates into an increase in market share of 0.4 percent.

The two-way trade of the smaller and somewhat less open Mexican economy also underwent a regional concentration. Mexico's two-way trade share from 1991 to 1998 rose from 76.5 percent

to 77.9 percent with the United States, and from 2.0 percent to 2.1 percent with Canada. But its share of imports from Canada have plummeted from their peak in 1994, and its concentration of exports and imports from the United States dropped in 1998.

Table 3: Mexican trade with NAFTA partners (millions of US$)

	United States		Canada		Total Trade	
Year	Exports	Imports	Exports	Imports	United States	Canada
1991	33,953	36,868	1,139	698	70,821	1,837
1992	37,468	44,279	1,000	1,052	81,747	2,052
1993	43,117	46,542	1,541	1,163	89,659	2,704
1994	51,943	57,009	1,470	1,600	108,952	3,070
1995	66475	53,995	1,979	1,374	120,470	3,353
1996	80,673	67,629	2,170	1,744	148,302	3,914
1997	94,531	82,182	2,157	1,968	176,713	4,125
1998	87,343	79,011	3,692	863	166,354	4,555
(shares of world trade)						
1991	0.795	0.739	0.027	0.014	0.765	0.020
1992	0.811	0.713	0.022	0.017	0.755	0.019
1993	0.833	0.712	0.030	0.018	0.765	0.023
1994	0.853	0.718	0.024	0.020	0.777	0.022
1995	0.836	0.745	0.025	0.019	0.793	0.022
1996	0.840	0.756	0.023	0.019	0.800	0.021
1997	0.856	0.748	0.020	0.018	0.802	0.019
1998	0.819	0.739	0.035	0.008	0.779	0.021

Notes: Total Trade is equal to Imports + Exports

Source: International Monetary Fund, Direction of Trade Statistics Yearbook, 1998; International Monetary Fund, Direction of Trade Statistics, Quarterly, June 1999.

Table 3 illustrates the changes after NAFTA came into effect in the trinational trade balance from the Mexican perspective. Mexican trade with the United States increased by 134 percent, equaling an increase in market share of 1.4 percent. Trade with Canada increased by 148 percent—an increase of 0.1 percent in market share.

In all three cases, with the exceptions noted, there has tended to be a continuous rise (if with some occasional fluctuation) over the decade, rather than any single step-level jump after NAFTA took formal effect.

D. Transborder Investment Flows

In examining NAFTA's immediate economic effects, it is important to accord foreign direct investment equal attention to that given to trade. This is for four major reasons, as follows:

First, in North America, transborder flows of foreign direct investment (FDI) are closely associated with trade. About 65 percent of Canada's and almost as high a percent of Mexico's manufactured exports to the United States take place not between anonymous buyers and sellers

in an open market but as intra-firm or intra-alliance transactions between firms and plants joined in an equity or negotiated arrangement (Zeile 1997, Weintraub 1994, Alcerreca-Joaquin 1997). In the case of Canada's exports to the United States, 40 percent of exports are between different plants or subsidiaries of the same multinational corporation, and an additional 25 percent between firms joined in some form of business alliance (e.g., for marketing, supply, distribution, research and development). With free market forces so heavily internalized within firms and business alliances, and with the NAFTA-driven dynamics of regional rationalization and integration in production intensifying this phenomenon, the corporate strategy of leading multinational firms assumes considerable relevance.

Second, and partly as a reflection of the above, in important respects NAFTA was an investment agreement as well as a trade agreement. Many of its most innovative provisions came in the new protection it provided for transborder investment. For example, the provisions of NAFTA's Chapter 11 to allow firms direct access to an international tribunal to settle disputes, when they alleged governments had engaged in harmful actions that were "tantamount to expropriation," represented a new step in international law and procedure.

Third, the results of existing modeling exercises, reported above, point to the important role that foreign direct investment, and the technology embedded within it, has in altering environmental performance in recipient firms and countries.

Fourth, as NAFTA took effect, there were already strong ties in FDI, as in trade, among the three NAFTA countries (excepting between Mexico and Canada). In particular, US-sourced FDI played a significant role in the Canadian and Mexican economies. In 1995, over 2,000 US-owned companies operating in Canada produced 9 percent of Canada's GDP. The United States was also Mexico's leading foreign direct investor, with the amount of the investment tripling from 1989 to 1996. While the United States was far less dependent on FDI, almost 1,300 Canadian-owned subsidiaries in the United States employed 704,000 Americans, a number second only to that of Japanese-owned companies (Fry 1997). It was through this existing basis of substantial direct investment integration that NAFTA's effects could be most immediately and intensely felt.

In assessing changes among the three North American countries, it is important to focus on direct rather than portfolio investment. The former carries with it a powerful package of capital, management, technology, distribution systems, reputation and markets. With the integrated production systems of TNCs, it also makes the diffusion of advanced technology more likely, as well as adherence to a corporate-wide set of high-level environmental standards.

Attention should be given to both "greenfield" investment and to acquisitions or expansions of existing facilities. It should include fully-owned investment, joint ventures and North American business alliances. Although it is useful to assess the annual flows of direct investment, where possible the emphasis should be placed on changes in stocks of foreign investment. The latter data (which include retained earning or subsidiaries and expansions of existing investment using money raised on domestic banking and capital markets) will incorporate the fullest range of investment alterations.

Currently, only inconclusive data are available for examining these topics. Information is most complete with regard to overall flows and stock of FDI. Even here, the differences in measurement criteria between the United States and Canada on the one hand (whose data examine actual transfers), and Mexico on the other (which measures approvals), makes direct comparison difficult. It is thus useful to rely on US government data to assess both the US-Canadian and the US-Mexican flows and stock changes and on Canadian data to assess the Canadian-Mexican flows and stock changes.

In exploring NAFTA-associated changes in transborder investment with a view to tracing their environmental effects, several factors are of importance:

- regional concentration of investment,
- sectoral investment shifts, migration and subsidies,
- technology transfer and diffusion,
- intracorporate integration in production,
- corporate concentration, and
- foreign portfolio investment.

Each of these factors is examined below, together with a summary of the dominant changes within it during NAFTA's first few years of operation.

1. ***Regional concentration of investment.*** This addresses how post-NAFTA FDI stocks (and secondarily, flows) among the three NAFTA countries, relative to the pre-NAFTA period and to non-NAFTA partners, have changed overall for each of the three countries. In all cases, transborder investment should be considered in the context of:

   a. domestic investment (including both net domestic investment and the percentage of an industry that is foreign-owned, by firms headquartered and owned in NAFTA and non-NAFTA countries);
   b. how investment from countries within and without NAFTA is concentrating inside, as opposed to outside, North America; and
   c. the geographic concentration of investment in particular countries and locations within each NAFTA country, including transborder production clusters or transportation corridors.

   As enactment of NAFTA approached, its investment rules were expected to result in increased NAFTA and non-NAFTA FDI in the United States (particularly in capital-intensive industries), as the center of the new NAFTA region, and in Mexico (in employment-intensive industries), due to the effect NAFTA's Chapter 11 and other factors had in opening the latter's economy. Less impact was expected in Canada, already more integrated into US-based production systems. Such increases in FDI were expected to be strongest in sectors that were included in the liberalization, and subject to the disciplines, of Chapter 11. Increased direct portfolio investment in Mexico and domestic investment (primarily in export-oriented industries that would benefit from NAFTA) were also considered likely.

Evidence from 1994 suggested these initial investment changes were taking place (Kirton 1998a). In the immediate post-NAFTA period, the United States gave a rising share of its outward FDI to Mexico (and a diminishing share to Canada), Canada increased its FDI stock in Mexico (while holding steady in the United States), and Mexican FDI in the United States rose between 1993 and 1994 (while remaining negligible in Canada).

After this initial concentration in Mexico and secondarily in the United States, however, the trend slackened. Mexico's share of US FDI outflows, which had risen from 3.3 percent in 1993 to 5.3 percent in 1994, dropped in 1995 to 3.4 percent (US$3.0 billion) and again to 3.1 percent (US$2.7 billion) in 1996. Canadian FDI flows into the United States rose steadily from US$1.3 billion in 1992 to US$7.1 billion in 1995, but dropped to US$5.7 billion in 1996. The stock of Mexican FDI in the United States, which had risen from US$1.0 billion in 1993 to US$2.3 billion in 1994 fell to US$2.0 billion in 1995 and again to US$1.0 billion in 1996. Mexican FDI in Canada remained very low, despite signs of new interest at the end of 1997 (with a prospective purchase of the Nova Scotia steel producer Sysco by a Mexican firm). Thus, over this longer period, there is no absolute movement of FDI from the United States and Canada to Mexico.

There is no firm base to conclude Canada is losing its attraction as a destination for US investment as Mexican locations become more attractive and as US locations appear the best from which to service the entire NAFTA marketplace. Yet Canadian and Mexican levels of US FDI remain higher than their share of the regional economy. Moreover, Canada's decline in the North American region is less than that in its global and G-7 FDI shares, pointing to an independent effect of NAFTA in enhancing Canada's desirability as an investment location.

In addition, the concentration of new investment should be considered for production or transportation in geographic locales that are environmentally fragile, stressed, or lack accompanying environmental infrastructure and supports. Such an investment concentration can also have effects on social organization and cohesion (as outlined below) as some local communities gain and others lose from investment shifts.

Of particular concern are FDI's concentration in and affect on:

a. the Mexican maquiladoras that border the United States;
b. particular production clusters that grow, or shrink, within an integrated North American region; and
c. the major transportation and transmission corridors and border crossings where investment concentrates.

There is only partial evidence on the geographic concentration of such investment. There is a clear post-NAFTA increase in investment in and production and trade from the maquiladoras. But this appears to be a result of exchange rate changes, differential demand in the US and Mexican economies, and locational pulls that value proximity in an increasingly integrated North American supply chain and production system. NAFTA's rules created incentives in the opposite direction by according over time to all of Mexico the advantages long enjoyed by the northern maquiladoras. Thus NAFTA-generated FDI does not appear to

be geographically concentrating in the already-stressed maquiladora region in northern Mexico.

There is limited evidence on concentration in particular geographic locales. In areas where NAFTA is reinforcing the geographic concentration of investment, as with cattle feedlots and processing and packaging plants in Kansas and Alberta, it is doing so where the available technology, resources and capacity for government regulatory oversight is relatively advanced. US-sourced FDI in the Canadian beefpacking industry is also increasingly centering in southern Alberta, with attendant stress on the local infrastructure and ecology.

In general, there is no evidence of strong concentration of FDI or NAFTA-associated domestic investment in particular regions such as north-south transportation corridors or environmentally-sensitive areas. However, more generally, as explored below, the increasing scale of locally-sourced raw materials, greater use of packaging and plastics, and intensification of transportation in intracorporate trade may increase environmental stress.

2. ***Sectoral investment shifts, migration and subsidies.*** The second factor is whether this investment is expanding most rapidly in relatively pollution-intensive or relatively clean sectors. Of particular interest is whether NAFTA-associated FDI constitutes a transfer of industries and plants with heavy environmental costs (including those for environmental regulatory compliance) from one country or locale in the NAFTA region to another and how the standards and subsidies compare in those locales. An analysis of investment migration should also include an analysis of whether plant reductions and closures, and plant openings and expansions in another country, are taking place in ecologically stressed locations. The need to consider the government policy of direct subsidization (including tax credits) to attract investment is important, given its ability to generate environmental gains from investment migration, and the lesser capacity of smaller and poorer governments in North America to compete for industry on this basis. Such transfers of investment can take the form of a physical move of an existing plant or an expansion or placement of new investment in one area at the expense of another.

   The evidence on investment migration or differential expansion and the environmental motives and consequences of such shifts is partial. The best developed of several studies demonstrates a trend of US FDI into Mexico in industries characterized as lower polluting (Cole and Ensign 1997). A recent study of the Canadian automotive parts industry indicates that necessity for environmental regulatory compliance was negligible as a factor influencing corporate strategy and production location decisions (Eden et al. 1997).

   A more detailed examination of sectoral shifts sustains this portrait. From 1993 to 1996 US FDI flows into Mexico were low in the automotive sectors, steady in computers, household appliances, and textiles apparel, but negative in chemicals (where total US investment declined 47 percent over the period) and printed products. In processed food and beverages, where more than 25 percent of total US FDI into Mexico is concentrated, US FDI stock rose from US$2.3 billion in 1993 to US$2.8 billion in 1994 but declined to US$2.3 billion in 1995. There is thus no general tendency for US investment to flow into sectors that are relatively high polluting.

The sectoral pattern of new US FDI into Mexico in the post-NAFTA period appears to be avoiding or declining in those sectors with a large ecological footprint (basic metals, industrial chemicals, and non-metal products) and concentrating in those with a smaller ecological footprint (textiles, metal products, food products). Such a pattern suggests that US industry is not moving its heavily polluting production to Mexico. This is consistent with the pattern of initial post-NAFTA investment in Mexico (Ramirez de la O. 1996a). With US FDI flows to Mexico in 1996 representing only 0.2 percent of US gross private domestic fixed investment that year, there has been no general migration of US firms (US TR 1997b, US ITC 1997b).

Little is known about the effect of subsidies offered to offset environmental compliance costs in attracting investment to particular jurisdictions. Anecdotal evidence, however, suggests such a subsidy was employed to attract a US-owned beef packing plant to Alberta.

3. ***Technology transfer and diffusion.*** The degree and speed of the spread of advanced technology from one firm to a related enterprise in the other NAFTA countries is a critical factor. Such a trend is promoted by regional production systems. It increases both technology transfer and diffusion to competing firms in the same industry, to related and non-related firms in the sector, and throughout the economy. Of particular relevance are technologies that improve overall efficiency and those directed at enhancing environmental quality.

   Little is known either about how NAFTA-associated FDI transfers environmentally-enhancing technology from one NAFTA country to another, or how that technology moves within countries to other firms, sectors and the economy as a whole. There is some evidence that FDI is a contributing source of technology transfer and diffusion (Kirton 1998). However, there are no studies dealing with these processes in environmental technologies or impacts specifically. The outflows of US and Canadian FDI into Mexico, reinforced by Mexican FDI into the United States, should improve environmental performance in the recipient countries, through capital modernization, technology transfer among affiliates, and investments in environmental equipment, infrastructure and management systems. This should be especially true as the surge of new investment took place in 1994 when environmental consciousness in North America was at its peak. Preliminary evidence from the 1995 interview program conducted for the NAFTA Effects project suggests that the anticipation and advent of NAFTA led to environmental investments in foreign-owned and domestically-owned firms in Mexico (CEC 1996a, Ramirez de la O. 1996a).

4. ***Intracorporate production and standards integration*****.** A further important factor is whether and how the NAFTA regime is increasing intracorporate trade and affiliated trade between and among the members. Such a process can be expected to encourage integrated production systems that make it more likely that plants operating in all three countries will adopt and follow a common set of standards and practices.

   There is no systematic evidence about how FDI and resulting intracorporate trade has led to uniform, high-level, region-wide industrial practices and standards. NAFTA has encouraged coordinated production in the automotive, telecommunications equipment, computer, electronic products, and textiles-apparel sectors, thereby increasing the export of high-value

US component and services to firms in Mexico and allowing Mexican firms to displace extra-NAFTA competitors (US TR 1997b). This increases the incentive of such firms to adopt the generally high levels of environmental regulations followed by parent corporations in the United States.

5. ***Corporate concentration.*** Also relevant is how FDI may be encouraging a trend toward concentration within industrial sectors by creating a smaller number of larger firms servicing the NAFTA marketplace. Firm size and concentration may have various effects, from enhancing the impact of poor corporate environmental performance to equipping the firms with the resources, visibility and thus the incentive to adopt best practices in its environmentally-relevant operations.

   There is limited evidence on concentration in particular sectors, in a few large firms whose resources and visibility enable and encourage them to perform at a high environmental standard. In the cattle feedlotting sector, the industry is concentrating in the United States, while four large US firms have come to dominate a Canadian beefpacking industry increasingly centered in southern Alberta.

6. ***Foreign portfolio investment.*** A final factor of is foreign portfolio investment, as it relates to and reinforces FDI, or substitutes for FDI, and provides domestically-owned firms with the finance for technological and production upgrades and expansion.

Together, the available evidence from NAFTA's first few years in operation suggests that NAFTA-associated investment has not had a negative affect on environmental quality overall, and may well have led to environmentally-enhancing impacts in several ways. Such a portrait is sustained by a more detailed examination of investment trends in North America in recent years.

The results of such a review are reported in detail in Appendix A. They suggest that trends in FDI are driven primarily by the global position of the United States as the world's largest outward and inward foreign direct investors. US outward FDI stocks surged in Mexico, but not Canada, in the years leading up to NAFTA, but have concentrated on Canada in the years since NAFTA took effect. NAFTA was the motivating force behind these expansions, as a vehicle of increasing economic integration in North America. But its overall effect was to enable both Mexico and Canada to maintain their share of outward US FDI in the face of intense competition from established and emerging markets overseas. A sectoral analysis shows that NAFTA had its greatest impact in enhancing FDI flows to Mexico and Canada in the manufacturing sector. Moreover, the anticipation rather than the aftermath of NAFTA led to the large outflows of portfolio capital from the United States to Mexico that Mexican industry needed to modernize.

It is evident that NAFTA has a clear impact on investment within North America, particularly in inducing US investors to expand their involvement in the Mexican and Canadian manufacturing industry. Particularly when assessed against trends in global investment, they did not give rise to any overall trends for investment to move to Mexico to take advantage of any lesser environmental regulatory performance, nor concentrate unduly in a US hub of an integrated region. Much more detailed research is required before firm conclusions can be drawn about the

precise environmental effects these investment changes have had through various mechanisms and in an overall sense.

E. Other Economic Conditioning Factors

To demonstrate the presence of a NAFTA connection in trade and transborder investment, it is necessary to take full account of the other macroeconomic and microeconomic conditions, not related to NAFTA, that affect trade and FDI flows. Among the most important factors that must be controlled are the major macro- and microeconomic processes within the three countries' domestic economies, and the macroeconomic impact of the countries' involvement in the international economy. Although the precise variables in these macro- and microeconomic processes vary according to the specific issue or sector under scrutiny, in general, the following should be considered.

1. ***Domestic macroeconomic forces.*** Relevant domestic macroeconomic forces include aggregate growth, income levels, demand, and consumption in the economy, as distinct from the scale effect of growth and production (and consumption) generated by trade liberalization itself. They also include inflation and interest rates arising from and affecting growth, transborder trade, and investment directly. An additional component is the demand for foreign capital, as affected by the rate of national savings and investment and the size of government deficits and debts. Together, these factors influence cyclic changes in price that can affect some sectors.

2. ***Microeconomic changes in each economy.*** Of increasing importance are the microeconomic changes in each economy, as it adjusts to the liberalization brought about by the GATT/WTO and other trade agreements, ongoing changes in the global economy, and the opportunities and challenges of new technologies. Important microeconomic processes include deregulation and privatization, as well as the condition of the domestic financial and banking systems and the availability of credit and insurance. Additional factors include employment levels, the structure of the labor market, and the structure and profitability of firms.

   The relevance of microeconomic processes of deregulation and privatization is evident, for example, in the case of electricity in all three countries. On the other hand, an important factor in the maize industry in Mexico is the condition of the domestic financial and banking system and the availability of credit and insurance to small producers.

3. ***Major fluctuations from international forces.*** International macroeconomic forces, and shocks, are relevant, particularly for internationally open economies such as Canada's. Indeed, the post-NAFTA period has witnessed wide swings and sudden shocks in exchange rates, balance of payments, foreign exchange reserves, and credit for all three NAFTA countries. The most important macroeconomic forces in the international domain are exchange rates, and the balance of payments deficits and surpluses among the NAFTA countries. Also important can be the volume and direction of portfolio capital.

4. ***Changes in weather and climate.*** Finally, it is often useful to consider here how ecological conditions occurring in the region can autonomously affect patterns of production in trade and investment. Of immediate relevance are changes in weather patterns including rainfall

and temperature. A severe drought in northern Mexico is said to have led to a sharp decline in the number of cattle from 1992 to 1996. Diminished rainfall lowers the level of reservoirs and results in less hydroelectric production in the three countries. Changes in temperature can also be important in affecting growing seasons and the volume of agricultural crops.

These macro- and micro-economic forces can and do exert a powerful independent effect on the economy and ecology of North America—one that can overwhelm any effect that NAFTA itself may have. However, the available evidence suggests that post-NAFTA North American trade often remains insulated from the impact of such changes. Indeed, the existence of an autonomous NAFTA effect is evident at times of change in direction of the macroeconomic forces most affecting trade and of failure of observed trade patterns to conform to the patterns they direct but instead to respond to the patterns directed by the provisions of NAFTA.

For example, in 1995 when the Mexican peso lost 45 percent of its value against the US (and Canadian) dollar, Mexican GDP contracted almost 7 percent, Mexican domestic demand fell 22 percent and Mexican imports from non-NAFTA countries dropped by 25 percent. However, the overall value of Mexican imports from the United States fell by only 2 percent. Mexican imports from Canada rose by 5.4 percent.

Some of these economic anomalies may be explained as pre-existing integration between US and Mexican firms, notably Mexican firms importing intermediate and capital goods from the United States in order to increase their exports of finished goods to the US market. Yet the results in the Mexican-Canadian case, where the NAFTA effect is likely to be largest (given the lower levels of pre-NAFTA integration and trade and investment flows), indicate the presence of a powerful NAFTA-generated trade effect. Such results, consistent with the new institutional economics and the results of the FTA liberalization, point to the importance of institutional rather than economic market forces in determining the direction and shape of post-NAFTA trade flows. They also point to the need to use techniques in addition to general and partial equilibrium modeling methodologies to account for some important changes (Ramirez de la O. 1996b).

Finally, the high concentration of NAFTA-associated trade and transborder investment in a few large firms, often TNCs in which market forces have been internalized and thus controlled, suggest that NAFTA's economic effects flow not only from macroeconomic market forces but from microeconomic organization and the corporate strategy of individual firms, business alliances, and households as production units.

This suggests that the way NAFTA-associated trade and investment affects the environment can usefully be assessed, for many current purposes, not only at a broad macro level through quantitative modeling, but through an examination of the operations of individual plants and firms, the physical infrastructure that services them, the social organization that surrounds them, and the government policy that regulates their behavior and that of their stakeholders. The following section outlines the factors and relationships on which to focus in exploring these processes that link NAFTA-associated trade and investment to ecological change.

IV. Linkages to the Environment

The environmental effects of NAFTA-associated trade and investment are often not direct, immediate, and unilinear. Rather, they depend for their effect on the particular operation of the firms and plants that produce the goods and services for the international or domestic market, and the physical infrastructure that supports the plants, brings their inputs and workers to them, and transports their goods to market. They further depend on the social system in which workers, owners, consumers, surrounding communities and other stakeholders interact and the way in which governments domestically regulate the activities of all. Even where a NAFTA rule is relatively clear, its ultimate effect on the physical environment often depends on how firms, authorities operating infrastructure networks, social organizations, and governments react to and implement it. It is thus vital to examine in detail the processes of production, infrastructure, social organization and government policy that lie behind aggregate changes in trade and transborder investment, and see how their operation directly generates pressures on, and supports for, the physical environment.

These intervening processes, or "linkages to the environment," are logically related to NAFTA in several ways. Some may be a direct, immediate result of NAFTA's legal, political, and economic forces. Others may be affected by NAFTA but also operate with sufficient autonomy to exert their own independent impact on how NAFTA affects the environment. Others may be an indirect or delayed result of NAFTA but also exert a mediating effect. Still others may be unrelated factors that operate independently but in doing so intersect with NAFTA-generated forces to affect the environment in different ways. And some, such as national government policy measures, may, in a reverse flow of influence, be sufficiently strong to offset the impact of NAFTA and even determine the shape the NAFTA regime itself takes over time.

To understand NAFTA's environmental effects, it is thus necessary to examine in some detail the operation of four linkage processes:

- production, management and technology;
- physical infrastructure ;
- social organization; and
- government policy.

A. Production, Management and Technology

The first linkage to the environment is the process employed by the production unit (usually a firm) that carries out NAFTA-associated trade and investment, or is otherwise affected by it, and the technology and management employed in this process. An analysis of the production unit at this micro level allows for a detailed examination of a broad range of NAFTA connections, and of its complex environmental impacts. It also permits a detailed tracing of the specific process by which NAFTA affects the environment. In so doing, it enables policymakers and other stakeholders to target potential interventions with precision, ensuring maximum effectiveness.

The environmental stresses and supports of NAFTA-associated production depend on the following variables:

- inputs,
- production efficiency,
- physical technology,
- management standards,
- product characteristics and prices, and
- sectoral and geographic concentration.

Each of these is discussed in turn below.

1. ***Inputs.*** This includes raw materials and other inputs to the production process, their sources, and the ecological capital (renewable and nonrenewable) they represent. In all cases, they may consume natural resources, or lead to greater emissions as they flow through the processing chain than would alternative inputs.

   For example, it is of environmental importance whether North America's electricity is generated by high-sulfur coal as opposed to wind or geothermal sources, whether maize or the feed grains for cattle feedlots is produced using high levels of pesticides, and whether the gasoline in North America's automobiles is produced with or without lead, sulfur or benzene.

2. ***Production efficiency.*** This focuses on the efficiency of the process which converts inputs into products. Highly efficient production processes reduce the volume of raw material and other inputs, generate fewer emissions, scrap and waste, and increase the overall profitability of the enterprise, including the funds available for technological modernization and environmentally-enhancing investments. Efficiency includes the degree to which scrap from one process within a plant or firm is reused internally as an input to another process or product.

   The competitive pressures intensified by NAFTA may produce a strong incentive to generate such production efficiencies. For example, some leading firms in the highly integrated automotive parts sector have a target and a record of "zero to landfill" production. The trend of the major automotive assemblers to rely ever more heavily on Tier 1 and Tier 2 suppliers for the development and supply of components and modules, and the use of "target pricing" with successful suppliers is generating a constant incentive to reap such efficiencies and thus lower costs and prices throughout the value chain.

   Thus far, post-NAFTA trends in trade and investment do not appear to be leading to greater emissions. In Mexico, most of the new maquiladoras are not in industries that produce many pollutants, such as steel or chemicals. Rather, most of them concentrate on electronics, car parts, advanced electrical equipment, electrical household appliances, computers and parts, and office equipment with relatively little and declining (per units of output) emissions.

   More generally, the emissions associated with particular firms, industrial plants and sites can be assessed by reviewing the data of such sources as the US Toxics Release Inventory and the Canadian National Pollutant Release Inventory. Over time, as these two inventories achieve greater data harmonization and the Mexican inventory begins generating data, they

can assist in assessing NAFTA's environmental effects. Such assessments, and those from national enforcement records, can provide a useful indication of which NAFTA-associated firms and industries are generating the greatest environmental stresses and fewest supports, and the particular geographical areas associated with the greatest environmental stress. In time, such data could contribute to computable general equilibrium models to help assess NAFTA's environmental effects.

3. ***Physical technology.*** This considers the physical technology employed in production, including technology that can increase overall efficiency (greater production with lower inputs, emissions and waste) and technology devoted specifically to environmental purposes (such as pollution prevention technologies). Of greatest general relevance is the modernity and transferability of the technology. It is important to examine the investment in and use of general and environmentally-specific technologies, their price, cost and effectiveness, the ability of the workforce to effectively employ them, and the speed of the innovation, development, adoption and diffusion of state-of-the-art technologies.

   Technology is a critical factor in increasing the overall productivity of the firm or sector. Such productivity increases can bring significant environmental benefits. Increased efficiencies bred by the use of the most modern technology in production generally impose less environmental pressure, allowing aggregate environmental impacts to be held constant with increasing levels of production. There are cases, however, where technical improvements can lead to the depletion of a renewable resource.

   The advent of NAFTA, and the new competitive incentives and resources which it has brought, have generated several significant instances of environmentally-enhancing technological modernization. In the maize sector in Mexico, it is fostering the use in corn production of high-precision farming, soil management techniques, integrated pest management methods. In the case of cattle feedlotting, there is a growing use of waste and water recycling and biotechnology to control methane emissions.

   More generally, technology is a critical factor in increasing the overall productivity of the firm or sector, and such productivity increases can bring significant environmental benefits. The static yields and low level of investment and technology in maize in Mexico in the 1990s point to the difficulties that low technology and poor productivity bring about.

   The resources to speed technological modernization can come significantly from foreign direct investment. This process appears to be underway in several sectors in Mexico. Recent increases in investment in food and beverages in Mexico have been directed mainly to beer, bottled mineral water, preserved foods and vegetables, alcoholic beverages, snacks and fast food stores. In most of these cases the foreign investor is in a joint venture with Mexican investors and contributes investment funds that have been used to increase manufacturing and export capacity. Much of this increase has come in the form of new plants that incorporate the latest technology, as efficiency has been a major driving force in the strategies of investors. This is regarded as essential for the firms to compete in the newly open, full North American marketplace.

In the sector of metallic goods and machinery in Mexico, FDI has been mainly in the auto industry. It takes the form of wholly owned facilities by US investors. This investment is focused on upgrading and re-tooling existing Mexican plants of auto firms. Such projects often entail extensive adaptation and modernization of the plants. This is also the case with engine plants. Here US investors have brought new models of engines and more efficient production facilities and processes. The new engines replace models (and technologies) that have been in Mexico since the 1970s and that were mainly acquired by state firms. Such firms were privatized in the 1990s and their plants overhauled by the new owners. The latter include Dina, Cummins, and Mercedes Benz, producers of truck engines and trucks.

The technology brought about by the new owners involves new models of engines, with considerably more efficient combustion, reduced noise and fewer emissions than the engines they replace. The plants were re-tooled to make production runs more efficient and cleaner. All of them introduced new emission control equipment and made environment a specific area in the plant's organization.

4. ***Management standards.*** This factor has at its core the dominant strategic management systems for production units and firms, in both their economic and environmental dimensions. It also includes strategies adopted or devised to respond to NAFTA-affected and other incentives, the presence and use of a high-standards environmental management system or industry-wide environmental code, and the way in which an "environmental culture" permeates management and the firm as a whole. Also relevant is the presence of outside stakeholders, including private citizen groups, in the operation of the environmental management systems.

   In general, NAFTA has helped foster the use of modern, high-level, high-quality environmental, health and safety management system standards within all plants, firms and their suppliers, wherever they are located within North America or oversees. NAFTA has accelerated the integration of manufacturing processes in North America, which compels producers to maintain steady flows of inputs and products countries. This is most evident in the auto industry, which now regards the whole region as a single site for production as well as being a single market. Other industries following the same trend are car parts, electronics, office equipment, chemicals, textiles, professional equipment, sporting goods and many consumer products.

   Many of North America's leading multinational corporations are now moving from a "reactive" concern with regulatory compliance to emphasize eco-efficiency—strategically and proactively considering the use of best environmental practices as a way of increasing the shareholder value of the firm as a whole. They thus employ the highest management system standards seamlessly throughout their global operations.

   This is also true for major multinationals headquartered and owned outside North America. In Mexico, NAFTA has encouraged many investments by European and Japanese car part manufacturers to produce electrical components, windshields, plastic and aluminum parts, and electronic equipment. These firms have incorporated the same technique of production as their parent companies in Europe and Japan use, as well as the same controls on emissions

and management of scrap and residual materials and water. They include many suppliers for vehicles made by VW, Mercedes and BMW, companies who demand that their suppliers follow the same high standards as they, the flagship firms at the center of the business network, do.

A similar process is at work in Mexico's maquiladoras. The plants of the third generation of maquiladoras follow high standards of efficiency, safety, and emission controls in their equipment, technology and organization. Managers follow detailed manuals and report on a constant basis to divisions in the US parent company. Supervision by US managers on the basis of US standards is intense, in particular with regards to environmental controls. More recently, very rigorous supervision has been introduced on maquiladora shipments to the United States to prevent drug smuggling. Appropriate standards for firms to avoid problems include strict control of the product flow and the contracting of transport firms and customs clearinghouses.

Environmental concerns and controls figure prominently in the standards adopted by foreign investors in the NAFTA region. Most of the investors acquiring positions in NAFTA are large, resourceful and visible firms. Most of these foreign investors are under great pressure to maintain a leading presence in key markets, but they face global competitors of similarly large size. This applies to automobile, oil, chemical, consumer goods, office equipment, computer, and service industries, the last ranging from telecommunications to banking. Such large firms adopt appropriate environmental standards in order to minimize contingent costs.

From an economic standpoint, there is a compelling case for using the same technical standards and management systems in the affiliates and subsidiaries of large Canadian or US manufacturing investors in Mexico as in their countries of origin. Most of the investments in manufacturing have been made with the objective of integrating the Mexican plant with the network of parent company facilities elsewhere. This means that the Mexican plant is part of a global program of production: what products are produced, and how, is centrally programmed, and the timing for delivery is critical to the efficient operation of the whole network.

This means that the Mexican plant must use the same production techniques as in the investing country. Whenever this condition is not met, the Mexican plant is closed temporarily for re-tooling or technological upgrade. This explains the major transformation in recent years of auto industry plants, as well as of those producing engines, office equipment, electrical appliances, and textiles.

For the same reason, the environmental controls are the same as those the parent company has in place in any plant of the same type in the world. This minimizes the contingent legal costs and potential fines or the closure of facilities by the local authorities. Such a closure or even the threat of it causes great disruption to any plant whose production participates in the foreign investor's global network of integrated, just-in-time production.

NAFTA has also facilitated the entry of smaller investors into Mexico by setting clear rules and providing certainty. Nevertheless, there is not yet an inflow of investments by small

firms. Substantial barriers to entry remain, such as the large operating scale needed in many sectors for profitable results. Overcoming differences between the country of origin and the destination country is another barrier, particularly when the latter is Mexico. Mexico has less advanced distribution channels than the United States or Canada, lower levels of bank financing, and insufficient infrastructure. These differences are a deterrent to small investors who lack the capital and resources to overcome them.

5. ***Product characteristics and prices.*** This factor includes the key environmentally-related characteristics of the product and its price, including the environmental emissions and supports flowing directly from this product. Relatively high prices for a product may sustain activity and prevent strategic or market-driven substitution of alternative products with different environmental impacts. Also important are the performance, use and ultimate disposal and reuse of the products. Attention should be placed on components of products whose effects are not yet fully known.

   Examples of the environmental consequences of such product characteristics abound. The case of Mexican maize shows that relatively high prices for a product such as traditionally-cultivated maize may sustain activity and prevent strategic or market-driven substitution of alternative products with different environmental impacts. The energy efficiency of electrical appliances and the reuse of newsprint has important environmental consequences. There are a host of concerns surrounding the environmental and health effects of additives in gasoline, such as MMT and MTBE. Likewise, mercury emissions from coal-generated electricity production have uncertain effects that warrant attention.

6. ***Sectoral and geographic concentration.*** This includes the size, number, relative share of production and geographic concentration of production units in the sector. NAFTA-induced competition, specialization and rationalization may well reinforce comparative advantage and produce a geographic concentration of production in a few large, well-endowed firms capable of serving the entire North American marketplace.

   Sectoral concentration may consolidate production in a few large firms with the resources and visibility to engage in state-of-the art environmental performance. It may also cluster production activity in environmentally permissive locations, where the ecosystem is not highly stressed and where environmental regulatory oversight by government authorities, and monitoring by citizens, is strong.

   Concentration in itself is not an environmentally enhancing, or endangering factor. Clustering of production in a few large firms in a single location may increase economies of supply and distribution, or lead to an accumulation of environmental stresses or supports. Although small-scale production is often more environmentally friendly, large production units can offer economies of scale that have the potential to be more efficient and thus less environmentally degrading. In general, profitable enterprises are better able to invest in environmentally friendly production methods, or provide more direct environmental supports.

   The environmental impact of sectoral and geographic concentration depends on a process of strategic calculation and adaptation by those managing production units, a process that can,

for example, enable those directing large units to invest in greater environmental controls. It is thus important to consider in detail the particular incentives that managers of large and small production units respond to, the strategies they adopt, and the role environmental values play in this process.

The evidence to date suggests the multifaceted environmental impacts that sectoral and geographic concentration, together with underlying strategic calculation by managers, have. In the cattle feedlot and beef packing sectors, NAFTA appears primarily to reinforce comparative advantage and concentrate production in a few large (US-owned) firms clustered in a single location (with its epicentre at Garden City, Kansas). These firms have the size, profitability, visibility, and international marketing power to induce the wider adoption of state-of-the-art production methods, technologies and management systems. Concentration does increase point source air pollution and waste management problems but also offers opportunities for recycling and easy regulatory oversight.

In the case of Mexican maize, economic and geographic concentration may diminish the diversity of inputs, such as seeds and genetic resources, and the array of technologies, in favor of a monoculture less able to withstand environmental shocks and more dependent on environmentally-demanding production methods such as irrigation and pesticides. Conversely, traditional small-scale production among many small households in the *ejido* sector does much to protect the often hilly landscape and associated water and forest resources.

In the electricity sector, concentration of production in older coal-fired units, centered in the US Midwest can compound environmental stress. Conversely, production throughout North America from numerous smaller enterprises engaged in co-generation, using wind or geothermal sources or adopting new technology turbines can exhibit improved environmental performance.

B. Physical Infrastructure

A second linkage process to consider relates to physical infrastructure. Much of the environmental impact of NAFTA-associated production comes from activity spread throughout and taking place across North America, often in or over otherwise uninhabited areas. Such activity takes place as inputs are transported to plants and products to markets; as plants rely on the water, wastewater and power generation infrastructure required for their operation; and as irrigation systems or other public works operate to sustain logistical and economic systems.

It is thus important to consider the character and environmental impact of the physical infrastructure that supports, sustains and connects the site-specific production units. Attention should be paid to the overall public and private investment in such infrastructure, the unused capacity of existing systems available for additional throughput, and the creation of, and need for, new systems (including those in new locations) to handle additional demand.

Physical infrastructure includes facilities in the public or private sector required to transport and transmit inputs and outputs of NAFTA-related production between suppliers, production sites, and markets, and to service production sites with basic inputs such as water, wastewater

treatment, energy, and communications. The transportation/transmission infrastructure includes, among other things, roads, railways, ports, aircraft and airports, electrical transmission corridors, telecommunication grids, pipelines, irrigation canals, locks, dams, trucks, railcars, bridges, grain elevators and warehouses. The service infrastructure includes such items as water and sewage plants, irrigation systems, telephone and telecommunications networks, and the local production and distribution of electricity.

Physical infrastructure plays a critical role linking trade and investment flows to the environment in several ways. In general, transportation patterns will vary and have differential environmental effects, according to NAFTA-associated economic growth, privatization, logistical efficiencies and mode shift, or import substitution and changes in transportation distances. Especially in an era of regionally rationalized production systems and just-in-time inventory, the absence of adequate or appropriate infrastructure can impede NAFTA's liberalization from creating the new trade volumes or flows that would otherwise arise. For example, the absence of interconnection capacity on the US-Mexican border has led to less US-Mexican electricity trade than the NAFTA regime encourages. Transportation and service infrastructure affects the location and volume of production (including transborder investment flows), and the location and quality of life enjoyed by the local communities that provide the workforce and supporting infrastructure for plants. In the agriculture sector, investment in hydro-agricultural infrastructure is critical to reaping the efficiency gains promised by NAFTA.

To a large degree, the provision and operation of such infrastructure is regulated by local and national authorities in their planning, siting, and environmental assessment activities. However, the NAFTA agreements placed importance on physical infrastructure in several ways. The region's transportation and transmission infrastructure was, in cases such as the Land Transportation Standards Subcommittee and its mandate for the transportation of dangerous goods, made the responsibility of the NAFTA institutions. Responsibility for service infrastructure in the high impact area immediately adjacent to the US-Mexican border was assigned to two institutions whose creation was catalyzed by the advent of NAFTA—the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADBank).

Governments have an important role to play in providing and regulating the creation and operation of physical infrastructure throughout the region. Physical infrastructure can also ensure that such production and its distribution and consumption is more or less environmentally friendly. In tracing the environmental impact of the physical infrastructure that supports and sustains the site-specific production units and connects them to their inputs, customers, and stakeholders, several factors are of interest:

- existing infrastructure capacity,
- correlation of capacity with concentrated activity,
- choke points,
- competitive corridors,
- transporation/transmission scale,
- intermodal shifts, and
- distancing effects.

Each is discussed in turn below.

1. ***Existing infrastructure capacity.*** The first factor is the capacity of the existing infrastructure to handle the existing and ongoing NAFTA-induced increments of production and transportation. NAFTA may direct trade toward sectors and toward geographic locations, where the existing infrastructure can absorb the new traffic and demands, thereby obviating the need for new investments, new routes, and associated impacts on the environment. This appears to be the most likely short-term scenario in the case of electricity, where technological solutions for interconnection and wheeling power appear able to provide a much more intensively used integrated regional grid with few new transmission corridors or even twinning of existing transmission lines required.

   However, NAFTA-associated trade and investment may generate production that follows a path leading to environmental stress. For example, in Mexican maize production, the NAFTA-associated transition from traditional to modern cultivation methods is weakening supports for traditional terracing techniques, and generating increased demands for mechanical irrigation systems and water.

   A more environmentally positive result has arisen in the real estate sector, where a large share of the new post-NAFTA investment in Mexico went to tourist resorts on Mexico's west coast, Baja California, and the Yucatán peninsula. These involved construction of resorts and development of infrastructure to provide water, electricity and sewage to areas that had been largely underdeveloped until then.

   Another portion of this investment went to the Santa Fe office and commercial development west of Mexico City. The Santa Fe area had been for decades a site of garbage collection that caused substantial air pollution and contamination as the garbage was under intense sunlight and completely exposed to winds. The Mexico City government started the cleaning and rehabilitation of this entire area in the late 1980s. The area is now a modern and clean site of office buildings and retail shops, with efficient use of space and green areas. Foreign investors from the United States, Canada and the United Kingdom took a major stake in this development.

2. ***Correlation of capacity with concentrated activity.*** A second factor is how well existing and new infrastructure capacity correlates, in place and form, with the new concentrations of NAFTA-associated economic activity. NAFTA-generated comparative advantage and specialization may concentrate new production activity at locations with an already well-developed transportation/transmission and local environmental infrastructure. While there will be additional environmental impacts from increased use, incremental additions to a well-developed and regulated network can minimize environmental stress. They may even result in environmental improvement by diverting activity from less efficient and more ecologically stressed regions.

   This appears to be the case with cattle feedlotting, which in the United States has come to be heavily concentrated along Interstate 35. That highway, running from Duluth to Laredo, has

its epicenter in Kansas, where more than 300 motor freight carriers are headquartered. It carries 74 percent of all goods traded between the United States and Mexico by truck. Such locations also feature advanced service infrastructure and waste management facilities.

In contrast, along the US-Mexican border, since NAFTA came into effect, increases in production designed for export to the United States and accompanying production and population concentrations continue to overwhelm the capacity of local infrastructure. However, these concentrations and resulting environmental stresses are not the result of NAFTA but of the 1995 peso devaluation that generated a need for Mexico to increase exports and sheer proximity to the US market. Indeed, NAFTA may well engender the geographic diffusion of production by giving, over time, to all of Mexico the special trade privileges long enjoyed by only the border region. Moreover, the negative environmental effects, due overwhelmingly to the lack of local environmental infrastructure, may be substantially diminished as the BECC and NADBank move into full-scale operation.

3. ***Choke points.*** NAFTA-generated trade may create choke points that generate local environmental stress where the transportation that carries trade increases or concentrates more rapidly than new transportation/transmission infrastructure can be constructed to service it.

   For example, Texas alone accounts for over half the 3,326-kilometer US-Mexican border. A substantial 40 percent of total US exports to Mexico move south along Texas highways and railways (Fry 1997, 8). This has raised concerns about the fumes and emissions from the heavy road traffic and idling trucks at border crossing such as Laredo, and the entry of substandard trucks from one jurisdiction into another.

4. ***Competitive corridors.*** Competition on the part of coalitions of subfederal governments and private sector actors may create new north-south corridors from Canada to Mexico, to service new NAFTA trade in ways that will benefit their local jurisdictions.

   For example, the Canamex Corridor runs from Edmonton to Mexico along US Interstate 15 and involves Alberta, Idaho, Arizona, California, Montana, Utah and Nevada. A parallel Rocky Mountain corridor currently contains extensive two-lane roads in southern Utah and northern Arizona. In Canada, no fewer than ten regional and corridor-specific initiatives have been launched. There is a possibility that such competitive corridor building may produce more local environmental stress than increasing the throughput of, or twinning, a single existing corridor. Government cooperation may also not keep pace with the new transportation demands. In the most recent comprehensive survey of subfederal linkages among Canadian provinces and US and Mexican states, there were very few involving both transportation and environmental authorities (Munton and Kirton 1996).

   Conversely, NAFTA may facilitate the foreign direct investment that integrates otherwise poorly connected single systems into a much more efficient and environmentally friendly north-south grid. The recent takeover of Illinois Central Railroad by Canadian National, as part of a single north-south system running from Canada to Mexico, appears to have these characteristics.

5. ***Transportation/transmission scale.*** The scale or volume of NAFTA-generated production, and thus of the transportation/transmission it requires, may increase fuel consumption, emissions, and accidents involving dangerous goods. Scale effects can be particularly environmentally endangering where there is no additional throughput capacity in existing systems, or where "twinning" existing systems (e.g., roads, rail lines, pipelines, electricity transmission corridors) is less economically desirable than constructing new ones in different locations.

6. ***Intermodal shifts.*** The NAFTA-associated intersectoral or "intermodal" shift from one form of transportation to another may produce a net move to more or less environmentally friendly modes. European evidence suggests that regional integration induces a shift from environmentally friendly sea and rail transport to less environmentally friendly road and air transport. There is a need to confirm the applicability of these findings to North America, particularly as partial data for Canada suggest a different pattern of environmental impact (CEC 1996a).

   At present, trucks transport about 80 percent of freight shipments between the United States and Mexico and 60 percent between the United States and Canada. Bottlenecks appear more extensive with rail and air than road transport, as parts of the southwestern United States and northern Mexico lack modern or standardized railroads, and the United States and Mexico are far from having an "Open Skies" regime. It would be useful to monitor whether the portion of truck transport increases in the future and study the changing environmental impacts that trucks, especially under NAFTA-wide regulations relative to rail, sea and air, have in the North American setting. It would also be useful to consider how new systems of electronic data transfer, by substituting for the movement of more weighty physical elements, might result in an overall reduction in environmental stress.

7. ***Distancing effect.*** Finally, it would be useful to examine the distancing effect associated with long distance transportation/transmission. The distancing effect refers to the move of the ecological footprint of production far from the awareness and sense of responsibility of the intermediate and ultimate consumers and of their political authorities. To date, NAFTA's institutions have had a variable record in producing high-level, region-wide, environmental regulations to govern transportation. Work in transportation of dangerous goods is proceeding rapidly, while that regarding automotive emissions seems to have reached a plateau.

C. Social Organization

The environmental impacts of NAFTA-associated production further depend on the way stakeholders operate collectively in networks of social organization. Such networks, with their bonds and obligations, add to and alter the impact of the rational incentives which economic calculations alone offer. Loyalties to family, local community, to other groups joined by non-market considerations, and to particular values may all effect how NAFTA-associated trade, investment, production and transportation unfolds.

Social organization has clear environmental consequences. Environmental enhancement flows from a well-developed network of social organizations that can add important environmental, cultural and public values to economic and market logic. Conversely, ecological stress can arise when a rapid inflow of migrant workers to new production locations overwhelms the environmental infrastructure and existing community supports, or when outwards migration leaves institutions and communities unable to carry out the traditional roles involved in supporting the environment.

In considering the environmental impacts of social organization, it is useful to examine six factors:

- civil society groups,
- property rights,
- culture,
- migration, and
- transnational coalitions and community formation.

Each is discussed in turn below.

1. ***Civil society groups.*** Social organization consists of well-organized and influential business, labor, community, consumer, and environmental groups, other cooperatives, and aboriginal communities. The strength of and balance among these groups is important, as it determines how effectively they can operate in response to market forces and are able to create a broader, more inclusive sense of community

   Different civil society groups react to and affect NAFTA-associated economic activity in various ways. Some business associations are engaged in pollution prevention and voluntary environmental standard-setting. An important component of social organizations are the voluntary environmental and other standards created, administered and accepted by the members of industry or professional associations. These can be created as needed in response to, in anticipation of, or as an alternative to, government regulation. They can also serve as the basis for regulation, as government-owned firms or departments adopt them or as they are referenced in government legislation.

   Traditional social units such as the family farm or *ejido* can be heavily affected by production changes flowing from NAFTA-associated trade and investment. The particular adaptation strategies they pursue are important in determining the environmental effects that ensue. For example, in the maize sector in Mexico, the incentives produced by NAFTA's liberalizations do not yet appear to have induced people in the *ejido* to abandon their traditional way of life and cultivation practices on a large scale.

   Environmental NGO's can be an important source of the injection of greater environmental awareness and custodianship into the practices and policies by which business and governments react to NAFTA-associated change. They have an important role in acting on behalf of citizens to foster transparency, openness and public participation.

2. ***Property rights.*** A second social factor is the system of property rights regimes that can provide resources for environmental supports or respect values other than short-term profitability. Important components are the extent to which surface and subsurface resources are publicly or privately owned, and the specific property rights which aboriginal or first nations communities have.

   The recent changes to the *ejido* sector in Mexico are of particular importance in this respect. Conversely, even within the market-based economy, NAFTA-related price changes can make relatively low-priced products such as beef more affordable to low-income consumers, and thus reduce lifestyle differences based on socio-economic class.

3. ***Culture.*** A third social factor consists of the cultural values shared by local and national communities that give daily activities significance and render them relatively immune from short-term, rational economic incentives. These values may include a sense of ecological preservation and custodianship that can be deeply rooted in a national or local community.

   For example, the central place that maize occupies in the culture of Mexico makes it less likely that traditional production methods will be drastically altered by new NAFTA-associated market forces. Explanations of patterns of migration themselves are not fully reducible to the rational structure of economic incentives but also reflect family and group networks that have arisen over time (Marichal 1998).

4. ***Migration.*** A fourth social factor is migration and associated demographic change. These consist broadly of community formation and change as workers and their families migrate from one location in the NAFTA region to another to take advantage of employment opportunities or to avoid unemployment (OECD 1998).

   The environmental effects of migration are complex. Sudden clustering of populations in ecologically sensitive areas, or locales without adequate environmental infrastructure, can cause environmental stress. It can also lead over time to the community organizations that demand environmental supports.

   Emigration can also relieve environmental stress (as when it leads to reduced farming on marginal lands). However, it can also reduce the availability of labor for social institutions that provide low-cost, community-based environmental supports (as with *ejido* labor in maintaining terraces and other labor-intensive supports for environmentally adapted rain-fed maize production in Mexico). NAFTA-induced concentration can place pressures on the family farm as the dominant production unit, and thus on the many rural communities which such farms sustain. More specifically, NAFTA's rules may have a direct environmentally-enhancing impact by allowing for the expanded temporary migration of business professionals, including those involved in the environmental services industries, migrant workers and tourists.

   Migration to, and population concentration in, border areas and crossings and along new NAFTA transportation corridors and production centers, is of environmental importance. Also of interest is NAFTA-associated rural-to-urban migration, and the resultant impact on traditional units such as the family farm.

In the electricity sector, for example, restructuring, by facilitating the delivery of low-cost electricity to any location in North America, should reduce undue pressures for industrial and migratory concentration. Here consumer and environmental groups in the United States and Canada are pressing, with some effect, for new regulatory regimes creating an "open grid" that would allow consumers from anywhere in North America to purchase electricity generated anywhere in North America from renewable sources. This electricity would thus be produced and transmitted in ways that promote energy efficiency and national environmental objectives.

5. ***Transnational coalitions and community formation.*** A fifth social factor of importance is the emergence of transnational coalitions and a common sense of North American community and identity across the region. Here, the processes of trilateralism and regional integration due to the NAFTA regime and its trade and investment flows may give rise to the development of trilateral transnational networks of civil society groups and a growing awareness of, and attachments to, a North American identity among individuals in the region.

   There is considerable evidence of the emergence of trinational cooperative networks within the business community. For example, in 1996, Mexico's National Livestock Council reached an agreement with the US National Cattlemen's Association to exchange information and promote beef consumption in Mexico. In 1996 they reached a trilateral agreement to pursue joint cattle export opportunities in Asia and Europe. Trilateral organizations of environmental NGOs and consumers have also arisen, although their strength and influence is uncertain.

   The emergence of trinational networks and identities can do much to affect the North American environment. The cooperation in voluntary, private sector–driven, multistakeholder standards-setting that has long flourished between Canada and the United States is now expanding to embrace Mexico. Voluntary standardization in environmentally-enhancing ways can be assisted by the NAFTA institutions, as they stimulate the work of such societal equivalents on a trinational basis. The intensification of integrated production systems on a region-wide basis through trade and investment can have a similar effect, particularly if the NAFTA institutions or ad hoc initiatives toward intergovernmental harmonization are unable, for other reasons, to move with sufficient speed or effectiveness.

   Evidence suggests, though, that relatively few of NAFTA's environmentally relevant institutions involve civil society groups (CEC 1997b). It further suggests that those institutions, insulated from concentrated industry involvement by multistakeholder participation or government-only operation, are more likely to rapidly generate high-level regional environmental regulatory convergence. At the same time, NAFTA has created innovative processes—as in the Chapter 11 dispute settlement mechanisms, and in NAAEC's Article 14-15 citizen submission process—that give private citizens direct access to international bodies.

   Beyond involvement in and the influence of the NAFTA institutions, the political and popular pressure for improved environmental controls has grown throughout the NAFTA region. This is an external factor that makes the presence of industrial plants with inferior

environmental standards potentially costly and risky, diminishing the likelihood that large foreign investors will be willing to engage in the practice. Contingent costs arising from different environmental standards are very difficult to calculate, while senior personnel must give too much costly time to legal and political problems that can arise from inferior standards.

Most generally, a common conception of regional identity and a sense of custodianship can ultimately offset the "distancing effect" noted above and foster high levels of environmental performance anywhere in the region.

D. Government Policy

A fourth process that determines how NAFTA-associated economic change might affect the environment is government policy. At the national and subfederal levels, government policy plays a major role in forwarding programs that can reinforce, offset or otherwise alter the impact of NAFTA liberalization. Through direct expenditures, tax regimes, credit, subsidies, user charges, set-asides and infrastructure and conservation programs, whether targeted to environmental purposes, to a particular sector, or to the economy as a whole, governments can provide important environmental supports at a level and with a focus tailored to the new environmental pressures NAFTA-associated production might bring. Governments also impose and enforce environmental regulations that respond to, or prompt, new developments in production and technology, and that can encourage a move to a high level of general and environmental regulatory convergence in North America. They can do so, and offer supports, where NAFTA is geographically or sectorally concentrating production activity. Intergovernmental action can facilitate the extension of such high standards and capacity through regulatory convergence and other forms of international cooperation.

The environmental effects of government policy depend most broadly on the balance of resources and linkages between state and society. In general, the responsiveness of the state to the social organizations and the transparency and meaningfully balanced involvement of civil society in decision-making should strengthen the demand and capacity for environmental enhancement. Moreover, a strong, resource-rich, high-capacity state is often required to protect the public good that the environment represents, as in the creation of national parks, the preservation of biodiversity, and the exercise of regulatory oversight over nonrenewable resources.

More specifically, the variables relevant when considering the role of government policy are:

- government intervention in the market,
- jurisdiction over environmental policy,
- balance between government branches,
- strength of market-oriented government policies,
- effects of specific government policies on the environment,
- environmental surveillance and enforcement, and
- trilateral cooperation at various governmental levels outside the NAFTA institutions.

Each is discussed in turn below.

1. ***Government intervention in the market.*** The broad forces of state-society balance and state capacity are first registered in the degree of government intervention in the market (or society), especially through the presence of state-owned enterprises. Although the three North American countries began the NAFTA era with different mixes of state-society relations, there has been a general move in all three countries to less governmental intervention. This move has varying environmental consequences.

   For example, the current restructuring in the North American electricity sector may lead to a lessening of public utilities' previous demand-side management programs, and their traditional role as an employer of last resort. At the same time, as detailed in Appendix A, in the case of Mexico's opening of electricity and gas distribution, restructuring can prompt the inflow of a whole range of environmentally enhancing technologies and practices. To take a roughly parallel example—the case of agriculture in Mexico—the 1991 amendment to Article 27 of the Constitution to allow private sector participation in *ejidos* has had varied consequences for their adjustment under NAFTA.

2. ***Jurisdiction over environmental policy.*** A second factor is the division of responsibility for environmental and environmentally-related policy between federal and subfederal governments. In addition to the three national governments, the North American region contains nearly 100 states, provinces, federal districts, and major territories. These are in turn subdivided into tens of thousands of counties and municipalities (Fry 1997). Of relevance is the degree of centralization within the three federal systems of the member countries, and the number, diversity and capacity of subfederal governments within each.

   The relatively highly centralized Mexican government contrasts with the extensive powers of the provincial governments within the Canadian federation, where an estimated 70 percent of the responsibility for environmental matters rests. The large number of states within the United States also creates great scope for regulatory diversity and can increase the challenge of coordination. As the case of cattle feedlotting suggests, environmental enhancement is increased when the standards mandated by environmental regulations are high in those particular subfederal jurisdictions where production activity is being concentrated geographically by NAFTA's dynamics of comparative advantage and other forces.

   An important issue is the degree of federal-provincial cooperation in matters relating to the environment, including enforcement (explored below). For example, the scope of Canada's full participation in NAAEC depends in part on an intergovernmental agreement among the federal and provincial authorities that governs the role of each. Also important is the effect of decentralization, a large number of subfederal units, and diversity in the environmental conditions and regulations among each in enhancing the competitive pressures stemming from NAFTA's liberalization. These may intensify incentives to lower—or at least not raise—environmental standards to seek competitive advantage. This may be particularly true where subfederal jurisdictions are contiguous (and thus exposed by low transportation costs) to those in partner countries, especially where such jurisdictions have an economy dominated by natural resource-based industries or relatively high polluting industries.

However, such diversity can also allow subfederal jurisdictions, some of whose environmental regulations are more stringent than those of federal authorities, to pioneer new and higher environmental standards that may become more widely adopted. Examples of such policy leadership include the "California effect" in automotive emission controls, the initiatives of Alberta and California in 1993 and 1994, respectively, to move to electricity restructuring, and policies to promote "green" electricity in some New England states.

In general, however, diversity can complicate the process of setting common nationwide standards, as indicated in the case of standard-setting among Canadian provinces for the transportation of dangerous goods. It may also raise the cost of trade and even impede it by requiring industry to produce products to meet different standards for several different jurisdictions, some of which contain a small market. At the same time, NAFTA's institutions and intergovernmental cooperation among its member governments (see below) can help overcome federal-subfederal differences to generate single, high-level regional standards.

3. ***Balance between government branches.*** A third factor is the balance within governments among the executive, legislative and judicial branches. In general, the coordinated or convergent involvement of all three branches in environmental policy is likely to promote environmental enhancement. Pertinent within the executive branch is the balance and relationship among environment, trade, foreign affairs, finance and industrial-sector ministries, and the role of central government in coordinating them. This would include the involvement of the head of state or government. An equal and integrated role for environment ministries and agencies, and the active involvement of leaders, will almost certainly lead to environmental enhancement.

4. ***Strength of market-oriented government policies.*** A fourth factor is the strength of government polices to ensure freely functioning markets, rather than monopolistic or oligopolistic concentrations that are asymmetrical in their policies of access, information disclosure and transparency, and accountability. This includes government policies and interventions to affect the macroeconomic and microeconomics forces discussed above.

   Environmentally relevant policies here include unilateral or accelerated tariff reductions, the provision of export credits, and regulations on FDI. An example of the latter is Mexico's 1995 opening of gas distribution to foreign investors. (See the Appendix for details.)

5. ***Effects of specific government policies on the environment.*** A fifth factor consists of the set of more specific government policies relevant to how NAFTA and its trade and investment flows affect the environment. These include policies directed both at government operations and outside society. The most important policies are as follows:

   a. **Procurement practices.** This includes policies and practices of both national and subfederal governments.

   b. **Environmental management systems used by state-owned enterprises.** This includes the use of systems, such as ISO 14000, by government departments and their operating facilities.

c. **Financial instruments.** These include taxes, credits, subsidies, and user fees. Examples are targeted financial incentives for customers to buy efficient appliances, subsidized water for irrigation for corn production in the United States, programs targeted to sustainability rather than income transfer or production of particular crops to agricultural producers, and the 1996 US Environmental Quality Incentive Programs (EQIP) for small livestock facilities to construct lagoons.

d. **Government research and development.** This includes the provision of technical assistance, and the level of and targets for such supports, as against the environmental stresses generated by NAFTA-associated production. The use of these programs by already affluent producers, or by those seeking to invest in particular production techniques (such as highly irrigated and pesticide-intensive agriculture) with high environment stress) is also relevant.

e. **Regulations, environmental assessment, and intellectual property rights.** These include regulations allowing access for producers and consumers to transportation networks/transmission grids, or imposing uniform charges for electricity efficiency. Also relevant are regulations for environmental assessment, which affect the siting decisions for electricity generation plants as well as their resulting environmental quality. Domestic and international regimes for intellectual property rights can be important factors.

f. **Environmental regulation of producers and products.** Relevant here are direct environmental regulation of producers (such as emission levels on old and new plants, US and Canadian regulations on beef processing and packaging), their inputs (for instance, minimum content requirements in electricity), their products (including disclosure requirements and eco-labels) and their consumers (such as automotive inspection and maintenance and end-use regulation of electrical appliances). Also of interest are environmental rules, such as the US NAAQS on SO_x and Mexico's 1994 regulations on SO_x and NO_x, which diminish harmful air emissions from electricity generation plants.

g. **Conservation programs.** This includes direct conservation programs, such as the US Soil Bank Act of 1956, its descendant—the USDA Conservation Reserve Program, and policies for national parks and natural protected areas.

6. ***Environmental surveillance and enforcement.*** A sixth factor is the capacity and performance of governments in environmental surveillance and enforcement, particularly in regard to sectors or locations under acute environmental stress, or in regard to substances likely to create it. This includes the capacity of governments for environmental reporting and monitoring, their capacity for inspection and enforcement, their levels and quality of inspections, and their use of various compliance-inducing measures.

7. ***Trilateral cooperation at various governmental levels outside NAFTA institutions.*** A seventh factor is trilateral cooperation at the federal and subfederal level on environmental issues. Such environmentally-related cooperation enhances environmental quality, notably when its deals with transboundary issues, but also when it relates to the global commons or

domestic practices and problems. As with cooperation taking place through the NAFTA institutions themselves, it can take the form of communication, capacity building and resource sharing, the upward convergence of standards and cooperation in multilateral forums.

Thus far, such cooperation appears to be limited at the subfederal level. At the federal level, while the NAFTA institutions appear to be the central forums for fostering such exchanges, there is considerable intergovernmental activity emerging on a trilateral basis. In the future, such cooperation could come to include far-reaching innovations, such as a region-wide emissions permit trading system to assist the three countries in meeting their climate change targets.

V. Indicators of Environmental Impacts Stemming from NAFTA

This section addresses the possible environmental impacts of changes from these four linking processes, as a foundation for identifying indicators that would be most useful at this stage to measure NAFTA-induced or associated effects. Of ultimate interest is how NAFTA-associated forces can or do create movement toward sustainability in each of the four major components of the ambient environment: air, water, land and living things. The measurement and monitoring of indicators will require different techniques according to the particular problem under analysis. In most cases, heavy reliance will be made on data already being generated and collected by environmental agencies other than the CEC.

This analysis begins by exploring the ways in which both pressures and supports acting on the ambient environment are created by these linkage processes. Environmental pressures are processes that increase the stress on the environment in its existing state by providing a further load on its absorptive capacity. Example of such pressures, or stresses, are pollution and emissions that flow from industrial and human activity. In the agriculture sector, in activities such as maize production and cattle feedlotting, beef processing and packaging, and associated feed grains production, environmental pressures can take several forms. These include dams and diversions for irrigation, overgrazing which causes soil erosion, water consumption in the feedlot, pesticide and agricultural chemical use, and food residues.

The impact of such pressures must be considered together with environmental supports, which can be created by the same processes. Supports include waste management practices, such as animal and nutrient management and manure disposal in cattle feedlotting. The social organization of maize production in Mexico, with its emphasis on communal terracing and the use of a wide variety of seeds as an insurance policy against natural conditions, creates important environmental supports for improving water quantity, preventing soil erosion and maintaining genetic diversity. Creating such supports may be the deliberate target of government policies, such as the establishment of natural protected areas, and thereby constitute responses to environmental pressures or to changes in the state of the ambient environment.

The impact of such mixtures of pressures and supports will vary according to the existing state of the natural environment in the geographic area and particular ecosystem they affect. Although it is very difficult to establish precise stability thresholds for specific ecosystems, of particular

concern are those instances in which small net increases in pressures over supports can have a major catalytic and potentially irreversible effect on the ambient environment, or where a small environmentally-enhancing intervention can generate large gains. Also of particular interest are high-impact locales—places where environment pressures concentrate to overwhelm the available supports. One such area may be the large hypoxic zone in the Gulf of Mexico at the mouth of the Mississippi river, resulting from the contamination of surface water from pesticide/fertilizer application in the US Corn Belt.

Of ultimate interest is the cumulative impact of such pressures and supports on the air, water, land, and biota that constitute the ambient environment of an entire ecosystem. It is thus important to identify a set of indicators that measures change in each of these four ambient domains. In doing so, it must be recognized that these major components of the ambient environment are interrelated in complex ways. It is the overall state of the ecosystem that is of essential concern. It is thus important to add more inclusive, "aggregate impact" indicators—those that measure the consequences of change in a particular aspect of the ambient environment on the natural ecosystem, human health, or the economy or society-at-large.

There are hundreds of possible environmental indicators that could be used for assessing the effects of NAFTA on the ambient environment at both a general or sector/issue level. However, resource constraints make it impossible to assess all of them and, in any case, not all are equally valid. Some indicators are clearly more important than others, as evidenced by their more frequent use in scientific and policy documents. The key indicators identified here are those that are nationally or internationally recognized for their importance. They are of particular relevance to the distinctive biophysical characteristics and ecosystems of the North American region and to the environmental issues at the forefront of public and policy interest in NAFTA. They should be considered in general analyses and by all sector/issue studies. Not all of these indicators will be relevant for every sector/issue study. However, this set can act as a starting point or checklist for identifying environmental effects at the same time that detailed sector/issue specific indicators are being developed and analyzed.

Several guidelines were used for identifying the key indicators identified below. The first was to include all pollutants for which there are national ambient standards, objectives or guidelines in Canada, Mexico or the United States. Eight air pollutants and 44 water pollutants (related to drinking water standards) fall into this set. Second, many of the environmental indicators currently recommended by the OECD and employed in that organization's environmental performance reviews of the three NAFTA countries make up an additional set. Third, these indicators are those which best meet the core methodological criteria of scientific validity, representativeness, responsiveness, early warning potential, data availability, accuracy and accessibility, understandability, comparability to reference points, comparability with indicators developed in other jurisdictions, cost effectiveness, and clarity. Fourth, they include some indicators that incline toward an aggregate analysis. These do so because they encompass more than one specific indicator within a single medium of the ambient environment, or they apply across different media. They may also connect indicators of the ambient environment with the pressure, state, response environmental model; with the four linkage processes (see **§ III** above); or with core economic dynamics identified above in **§ II**.

The following list of indicators, generated according to these criteria, concentrates on those where reliable cross-national data is currently available, so that application of this framework might proceed immediately. In the longer term, this should become a less important constraint on the selection of indicators, as additional environmental data becomes available and monitoring efforts expand. The list thus emphasizes indicators relating directly to the four dimensions of the ambient environment (air, water, land, biota) and aggregates impacts on ecosystems as a whole. A balance across all four ambient domains has been sought, within the constraints set by ease of measurement and resulting data availability. Within each of these four ambient domains, an effort has been made to include indicators relating to pressures, states and supports or responses.

A. Air indicators

Air, or the atmospheric environment includes local and regional air quality, pollution levels, and broader processes, such as stratospheric ozone depletion and climate change. There is a standard list of indicators of atmospheric quality generally accepted by the scientific community (Masera and Maclaren 1996; CEC 1996a, 114). Many of these are employed by federal governments of the NAFTA countries in their overall and sector-specific environmental monitoring programs. For example, US livestock facilities are subject to the National Ambient Air Quality Standards (NAAQS) under the Clean Air Act for six compounds: carbon monoxide, ozone, particulates, sulfur dioxide, nitrogen oxides, and hydrocarbons.

At present, the core air indicators best used to assess the environmental change associated with NAFTA are as follows:

1. ***Acid preciptation.*** The acidification of lakes and rivers diminishes their ability to support aquatic life. Acid precipitation and dry deposition, caused principally by emissions and concentration of sulfur oxides (SO_x), primarily sulfur dioxide (SO_2), damage forests and ecosystems as well as buildings and highways, accelerate leaching of metals from rocks and soils, and decrease agricultural outputs. Effects on humans include eye and respiratory system irritation. Children and those with respiratory disease are particularly susceptible.

2. ***Ozone (O_3) concentration*.** Ground-level ozone, the primary component of smog, is an important air pollution problem shared by all three countries. High concentrations can lead to inflammation of the respiratory tract, respiratory illness in children, reduced pulmonary function, a decreased capacity for work and exercise, and even death. Individuals with heart or lung disease are more susceptible to all of these symptoms. It also damages crops and ornamental plants. Principal ozone precursors (in combinative reactions catalyzed by sunlight) are:

    - **Nitrogen oxides (NO_x).** These ground-level ozone precursors also contribute to acid precipitation, dry deposition and photochemical smog. They are chiefly produced by high-compression internal combustion engines, as well as by some industrial furnaces, and by lightening.

- **Volatile organic compounds (VOCs).** VOCs are produced by fossil fuel combustion, as well as by incinerators, gasoline and petrochemical vapors, paints and solvents, and various industrial processes.

3. ***Particulate matter (PM).*** This is a broad category of air pollutants that includes a range of small solids or liquids that vary in size and chemical composition. Some particles are acidic "acid aerosols." There are particle categories that include toxic substances, such as heavy metals, polycyclic aromatic hydrocarbons, as well as numerous other organic compounds. Anthropogenic sources include industrial activities, incineration, agriculture, construction, and mobile sources. PM is commonly divided by size fraction:

   - **PM_{10}** consists of fine particles 10 microns or less in diameter. These inhalable particles have been implicated in chronic lung disease since 1979. They are also associated with pulmonary and heart disease and are major contributors to urban haze. PM_{10} can reside in the atmosphere for hours or days before settling to earth.

   - **$PM_{2.5}$** refers to the smallest and most dangerous fraction of particulate matter, those particles 2.5 microns or less—an estimated 60 percent of PM_{10} particles. They may include a wide range of toxic metals and chemicals as well as sulfates and nitrates. $PM_{2.5}$ have been implicated in cardiopulmonary illnesses, premature death due to respiratory disease, reduced pulmonary function, and bronchitis.

   - **Elemental metallic particulates.** These can include toxic heavy metals, such as mercury (Hg) and lead (Pb). In biological systems, these are persistent and bioaccumulative, causing cancer, birth defects, organ damage, and disorders of the nervous system. Mercury, especially, can re-volatilize and be re-injected into the atmosphere by a variety of mechanisms, moving hundreds or thousands of kilometers from its original sources.

4. ***Persistent organic pollutants (POPs).*** These are organic molecules, often of extremely high toxicity, characterized by low water and high fat solubility. This causes them to bioaccumulate to high levels as they move up the food chain. Many POPs are pesticides—such as mirex, toxaphene, DDT, and chlordane—and others include polychlorinated biphenyls (PCBs), dioxins and furans, and various other byproducts of industrial processes. Some POPs are now known to function as endocrine disrupters and interfere with the functioning of hormones. Others may be responsible for declining sperm counts and rising levels of birth abnormalities among certain human populations and affected animal species.

5. ***Carbon monoxide (CO) emissions and concentration.*** This compound impedes the absorption of oxygen into the bloodstream, causing headaches, nausea, fatigue, and impairment of judgement. In extreme concentrations, it is lethal. Produced by mobile sources and fossil fuel combustion, in terms of volume, it is the single most important component of air pollution. CO oxidizes readily in the atmosphere to form carbon dioxide, which is involved in the cycle of global warming.

6. ***Carbon dioxide ($C0_2$).*** The fourth most abundant gas in the earth's atmosphere, carbon dioxide poses no direct threats to human health. However, the gas is implicated in global warming through its contribution to the greenhouse effect, and its output from combustion activities in developed and developing countries is probably exacerbating this phenomenon.

Further development and use of this framework should concentrate on establishing the cross-national comparability of such scientifically and governmentally accepted core indicators. This process could begin with those dimensions currently in the forefront of scientific interest and closely associated with such economy-wide practices as electricity generation and automobile transportation—notably particulate matter, ground-level ozone and sulfur dioxide. It might also include other air quality parameters that arise in particular industries of interest and which are not currently subject to widespread or full federal and subfederal monitoring. In the case of cattle feedlots, for instance, such parameters could include dust, ammonia emissions from manure and dust, particulates, methane, and reactive organic compounds. It could also focus on emissions not yet widely monitored but considered important, such as mercury emissions from electricity generation, or on ensuring that such national monitoring programs and regulations are introduced on a comparable, region-wide basis.

Table 4: Air indicators

Indicator	Source/ Organization	Countries	Objective	Measurement unit	Smallest spatial scale	# of locations	Time period	Frequency
Acid precipitation	OECD OECD Environmental Data Compendium—1997	Canada, Mexico	none	mean annual pH, concentration of $SO_4^{=}$ (mg/l) concentration of NO_3^{-} (mg/l)	national	n/a	Canada (1980–95) Mexico 1990–95	unknown
	DDF (Department of the Federal District) Government of Mexico www.ine.gob.mx/indicatores/ingles/indice amb.htm	Mexico	none	pH of precipitation (pH<5.6=acid)	municipal (urban)	unknown	1987–95	annual
SO_2 (and SO_x) emissions	Environment Canada—National Emissions Inventory of Criteria Pollutants http://www.ec.gc.ca/pdb/pdb_e.html	Canada	none	tonnes by sector	state/ provincial	unknown	? to present	annual
	INE (National Institute of Ecology) http://www.ine.gob/indicadores/ingles/ca2_31.htm	Mexico	none	tonnes/year	municipal (urban)	32	1994	annual
	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, Mexico, United States	none	total emissions (tonnes), % change since 1980	national, municipal (urban)	2 per country	1980–mid-1990s	unknown

SO_2 concentration	Environment Canada—NAPS database	Canada	desirable: 11 ppb, 30 µg/m^3 (annual) acceptable: 23 ppb, 60 µg/m^3 (annual)	µg/m^3	monitoring stations	84	1974–present	monthly
	INE (National Institute of Ecology) www.ine.gob.mx/indicatores/ingles/indice amb.htm	Mexico	0.13 ppm (1 hour) 0.03 ppm (annual)	ppm, IMECA (Mexico's air quality index)	municipal (urban)	5	1988–96	Annual
	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	0.03 ppm, 80 µg/m^3 (annual)	ppm	monitoring stations	759	1993–98	annual
	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, Mexico, United States	none	µg/m^3	national, municipal (urban)	2 per country	1990–95	annual
Ozone (O_3) concentration	Environment Canada NAPS	Canada	30 ppb	ppb	monitoring stations	50	1974 to present	monthly
	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	0.08 ppm, 157 µg/m^3 (8-hour average)	ppm	monitoring stations	1042	1993–98	annual
	INE www.ine.gob.mx	Mexico	0.11 ppm (1 hour)	ppm, IMECA (air quality index)	municipal (urban)	5	1988–96	annual
Total column ozone	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, Mexico, United States	none	total emissions (tonnes), % change since 1980	national, municipal (urban)	2 per country	1980–mid-1990s	unknown

Nitrogen oxides								
NO_2 (and NO_X) emissions	Environment Canada—National Emissions Inventory of Criteria Air Pollutants www.ec.gc.ca/pdb/pdb_e.html	Canada	none	tonnes by sector	state/ provincial	unknown	? to present	annual
	DDF and state governments	Mexico	none	tonnes per year by sector	municipal (urban)	32	1994–95	annual
	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, Mexico, United States	none	total emissions (tonnes), % change since 1980	national, municipal urban	2 per country	1980–mid-1990s	unknown
NO_2 concentration	Environment Canada—NAPS database	Canada	desirable: 32 ppb, 60 µg/m^3 (annual) acceptable: 53 ppb, 100 µg/m^3 (annual)	ppb	monitoring stations	50	1974 to present	annual
	US EPA—AIRS Data www.epa.gov.airsweb/info.htm	United States	0.053 ppm, 100 µg/m^3 (annual)	ppm	monitoring stations	420	1993–98	annual
	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, Mexico, United States	none	µg/m^3	national, municipal urban	2 per country	1990–95	annual
	INE www.ine.gob.mx/indicatores/ingles/indice amb.htm	Mexico	0.21 ppm (in 1 hour)	ppm, IMECA (air quality index)	municipal (urban)	5	1988–96	annual
VOC emissions	Environment Canada—National Emissions Inventory of Criteria Air Pollutants http://www.ec.gc.ca/pbd/pdb_e.html	Canada	none	tonnes by sector	state/ provincial	unknown	? to 1998	annual
	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	none	tons per year	country	unknown	? to present	annual

Particulate matter (PM)								
PM_{10} concentration	Environment Canada	Canada	?	µg/m3	monitoring stations	unknown	1995 to present	monthly
	US EPA—AIRS Data	United States	50 µg/m3 (annual)	ppm	monitoring stations	1759	1993–98	annual
	INE DDF	Mexico	150 $\mu g/m^3$ (24-hr max), 50 $\mu g/m^3$ (annual)	$\mu g/m^3$	municipal (urban)	5	1988–94	annual
PM_{10} emissions	Environment Canada—Pollution Data Branch	Canada	none	tonnes by type of industry	state/ provincial	unknown	1995 to present	annual
	Environment Canada—National Emissions Inventory of Criteria Air Pollutants	Canada	none	tonnes by sector	state/ provincial	unknown	1995 to present	annual
	US EPA—AIRS Data	United States	none	tons per year	county	unknown	? to 1998	annual
$PM_{2.5}$ concentration	Environment Canada	Canada	?	$\mu g/m^3$	monitoring stations	unknown	1995 to present	monthly
	US EPA—AIRS Data	United States	15 $\mu g/m^3$ (annual)	ppm	monitoring stations	unknown	1993–98	annual
$PM_{2.5}$ emissions	Environment Canada—Pollution Data Branch http://www.ec.gc.ca/pdb/cac/cacdoc/1995e/pm25_95.htm	Canada	none	tonnes by type of industry	state/ provincial	unknown	1995 to present	annual
	Environment Canada—National Emissions Inventory of Criteria Air Pollutants	Canada	none	tonnes by sector	state/ provincial	unknown	1995 to present	annual
Pb concentration	Environment Canada—NAPS database	Canada	none	$\mu g/m^3$	monitoring stations	118	1974 to present	monthly
	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	$\mu g/m^3$ (3-month average)	ppm	monitoring stations	465	1993–98	quarterly
	INE www.ine/gob.mx	Mexico		IMECA (air quality index)	municipal (urban)	5	1993–96	annual
	DDF	Mexico	$\mu g/m^3$ (3-month average)	$\mu g/m^3$	municipal (urban)	5	1986–95	seasonal

Pb emissions	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	none	tons per year	county	unknown	? to 1998	annual
	DDF and state governments www.ine.gob.mx	Mexico	none	tonnes per year by sector	municipal (urban)	32	1994–95	annual
CO concentration	Environment Canada—National Air Pollution Surveillance (NAPS)	Canada	desirable: 5.2 ppm, 6 mg/m^3 (annual) acceptable : 13.1 ppm, 15 mg/m^3 (annual)	ppm	monitoring stations	53	1974 to present	monthly
	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	9 ppm, 10 mg/m^3 (8-hour average)	ppm	monitoring stations	552	1993–98	annual
	INE (National Institute of Ecology) www.ine.gob.mx	Mexico	11 ppm in 8 hours	ppm, IMECA (air quality index)	municipal (urban)	5	1988–96	annual
CO emissions	Environment Canada—National Emissions Inventory of Criteria Air Pollutants www.ec.gc.ca/pdb/pdb_e.html	Canada		tonnes by sector	state/ provincial	unknown	? to present	annual
	US EPA—AIRS Data www.epa.gov/airsweb/info.htm	United States	none	tons per year	county	unknown	? to present	annual
	DDF and state governments www.ine.gob.mx/indicadores/ingles/indice	Mexico	none	tonnes per year by sector	municipal (urban)	32	1994–95	annual

B. Water Indicators

The second sets of indicators includes those dealing with the quality and quantity of water in inland, coastal and underground areas, its use for purposes ranging from irrigation to drinking, and its subjection to the discharge of effluents and compounds such as pesticides and fertilizers. Water is both an essential part of the ecosystem and human health and a basic resource for most economic activities and processes.

Water quality is directly affected by the activities in specific sectors. For example, agriculture is the primary cause of surface water impairment nationwide in the United States. Groundwater, which supplies half the US population with drinking water, and is the sole source for most rural communities, is a resource that is renewable only over long periods of time, and is subject to contamination from such substances as pesticides and nitrates in fertilizers. There is also concern in some locations regarding water quantity—for instance, in the Ogallala aquifer underlying the US Great Plains.

There are standard indicators of water quality and quantity generally accepted by the scientific community (Masera and Maclaren 1996; CEC 1996a, 114). At present, the core water indicators best used to assess the environmental change associated with NAFTA are as follows:

1. ***Quality of Drinking Water.*** This considers the presence of such harmful contaminants as VOCs, pesticides, PCBs, semi-volatile synthetic organic contaminants, antimony, arsenic, barium, beryllium, cadmium, chromium, cyanide, fluoride, mercury, nickel, nitrate, nitrite, and selenium. These contaminants are known to cause a wide range of health problems.

2. ***Freshwater use (by source/sector).*** Overuse of water resources can result in low river flows, water shortages, salinization of groundwater in coastal areas, loss of wetlands, desertification and declining sustainability for agriculture.

3. ***Lead (Pb) Concentration.*** Concentration has adverse effects on human health.

4. ***Copper Concentration.*** High concentrations kill fish and cause brain damage in higher animals.

5. ***Surface Water Pollutants.*** These include suspended solids, fecal coliform bacteria, and the total content of phosphorus, nitrates, dissolved oxygen (related to biological oxygen demand—BOD). Fecal coliform bacterial level is an indicator of the possible presence of pathogens. Nitrates and phosphates are the primary substances that cause eutrophication of lakes and rivers. Reduced levels of dissolved oxygen affects the ability of a body of water to assimilate wastewater and to support fish and aquatic plant life. Extreme conditions, such as at the mouth of the Mississippi River, result in “dead” zones incapable of supporting life.

6. ***Fish Capture***. Conservation of fish stocks requires a balance between biological productivity and harvesting rates. Lower fish captures can indicate water quality problems.

7. ***Sewage Treatment Connection Rates.*** Discharge of untreated used water is one of the prime causes of water contamination. This element of physical infrastructure is an indicator of efforts to decrease pollution loads.

Further development of the framework could usefully concentrate on reliable cross-national information gathering and monitoring of that subset of indicators which is critical in environmentally salient sectors such as agriculture. Such a list for agriculture would include five indicators: (1) nitrates in groundwater at a threshold of less than the EPA drinking water standard of 10mg/L; (2) atrazine (a corn herbicide, the most frequently detected pesticide and a possible carcinogen) in ground and surface water; (3) phosphates, which cause oxygen depletion in water, eutrophication, and algae growth, in concentrations of as little as 0.05 mg/L; (4) biological oxygen demand (BOD)—which the EPA uses as a standard measure; and (5) and total suspended solids (TSS)—a measure also used by the EPA (Runge et al 1997a, 82).

Table 5: Water indicators

Indicator	Source/Organization	Countries	Objective	Measurement unit	Smallest spatial scale	# of locations	Time period	Frequency
Freshwater use (by source/sector)	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	overall estimates (m^3/capita/year) as % of total resources, estimates by use category (municipal, industrial, irrigation)	national	n/a	1980–95	unknown
Lead	OECD Environmental Data Compendium—1997	Canada, United States		µg/L (annual mean)	national	n/a	1980–95	unknown
Ammonium	OECD Environmental Data Compendium—1997	United States, Mexico	none	mg/L (annual mean)	national	n/a	1980–95	unknown
Cadmium	OECD Environmental Data Compendium—1997	Canada, United States	none	µg/L (annual mean)	national	n/a	1980–95	unknown
Chromium	OECD Environmental Data Compendium—1997	Canada, United States	none	µg/L (annual mean)	national	n/a	1980–95	unknown
Copper	OECD Environmental Data Compendium—1997	Canada, United States, Mexico	none	µg/L (annual mean)	national	n/a	1980–95	unknown
Surface water pollutants (suspended solids, fecal coliform, total phosphorus, nitrates, dissolved solids, dissolved oxygen)	US Geological Survey (1990) US EPA, Office of Water *Environmental Indicators of Water Quality in the United States* (June 1996)	United States	none	% of stations showing changes in concentration levels (downward trend, upward trend, or no trend)	national	unknown	1980–89	annual
Fish capture	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	% of world capture, trends in total catch compared to 1980 levels, marine catch as % of total catch	national	n/a	1980–95	unknown
Sewage treatment connection rates	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	% of population connected with primary/secondary/tertiary or no treatment	national	n/a	Canada & United States (1980–mid-1990s) Mexico (mid-1990s)	unknown

C. Land Indicators

The third set of indicators relates to land. It includes soil quality and patterns of land use, including agriculture, forest cover and natural protected areas. Soil degradation is the most serious threat to the agricultural industry over the long term. Agricultural pesticides, acid rain from burning of fossil fuels, deforestation from over-harvesting of timber, and poor waste management practices can adversely affect soil health. In certain parts of North America, soil erosion due to deforestation already contributes to pollution of local streams and lakes. On other parts of the continent, valuable agricultural land is lost each year from poor cultivation practices. Shifting trade patterns under NAFTA, particularly those involving timber harvesting, agriculture or mining operations, could affect soil health by advancing or slowing the rate of erosion, the level of salinity, or chemical contaminants contained in soil. Urban development spawned by NAFTA-associated investment may also encroach on agricultural lands, affecting productive capacities. Finally, hazardous and solid waste disposal arising from industrial activities can lead to widespread soil contamination.

A general set of indicators to measure the major effects of NAFTA-associated activity on soil is as follows:

1. ***Intensity of pesticide use for agriculture.*** This component of production, technology and management is important because pesticide use adds persistent organic chemicals to ecosystems. Pesticides accumulate in soils and biota and are passed on to humans through food and water consumption. Residues leach into surface water and groundwater.
2. ***Nitrogen from fertilizers and livestock.*** Overabundance of nitrogen may exceed the assimilative capacities of soils. The surplus may seep into groundwater or run off into surface waters, contributing to eutrophication.
3. ***Area of forested land.*** Forests have many functions, including provision of timber and other wood-derived products, recreational benefits, and ecosystem services. They provide habitat in support of biodiversity and act as carbon sinks.
4. ***Intensity of forest use.*** Clearcutting and over-producing through unsustainable harvest rates cause loss of habitat and affect wildlife survival.
5. ***Waste generation.*** This is best considered by type: household/municipal, hazardous, industrial, and nuclear. At its most benign, waste disposal consumes land. If improperly managed, especially with hazardous substances, disposal can have significant impacts on human health and the environment.
6. ***Recycling rate.*** Recycling reduces the need for waste disposal.

In a specific sector such as agriculture, attention should focus on indicators of soil erosion, conservation and other tillage methods, soil runoff (of substances such as nitrates), fertilizer and pesticide buildup from over-application, the overuse of marginal land from expanded agricultural production, land left fallow, and land conversion. The spread of highly mechanized cultivation techniques and irrigation suggest themselves as priority indicators.

Table 6: Land indicators

Indicator	Source / Organization	Countries	Objective	Measurement unit	Smallest spatial scale	# of Locations	Time period	Frequency
Intensity of pesticide use for agriculture	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	active ingredients in kg/km^2, % change since 1980	national	n/a	1980–mid-1990s	unknown
Nitrogen from fertilizers and livestock	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	tonnes per km^2, % change since 1980 (compared to total agricultural output and GDP)	national	n/a	1980–95	unknown
Area of forested land	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	area as % of total land area	national		1970s–95	unknown
Intensity of forest use	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	harvest as % of annual growth, % change in annual harvest, annual growth and growing stock since 1980	national	n/a	Canada & Mexico (1980s–90s) United States (1980s–90s)	unknown
Waste generation	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	household or municipal in kg/capita, % change since 1980	national	n/a	Canada & United States (1980–mid-1990s) Mexico (mid-1990s)	unknown
Recycling rate	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	% recycled (paper & cardboard, glass)	national	n/a	Canada & United States (1980–96) Mexico (1990–96)	unknown

D. Biodiversity Indicators

The fourth set of indicators deals with biota, or living things. Biota encompasses overall biodiversity, including all forms of living organisms, including animals, plants, micro-organisms, and humans. Flora and fauna are adversely affected by the pollution of soils, water and atmosphere that results from industrial activities and intensive agriculture and forestry. The loss and fragmentation of forests and wetlands (either through nonsustainable harvesting or conversion to other land uses) can also spell disaster for biodiversity. Animals and plants are an essential part of the environment and also serve as economic resources for human activity. Indicators should therefore reflect both aspects.

The core set of general indicators for biota are below.

1. ***Number of threatened/extinct species.*** Many ecological processes depend on wildlife, including native mammals, birds, fish, reptiles, amphibians, plants and, especially, insects.

2. ***Wetlands.*** Wetlands store and allow the slow release of large quantities of water, provide protection from erosion, provide habitat for waterfowl and fish, and offer recreational opportunities.

3. ***Protected areas.*** Healthy natural habitat of adequate size is necessary for species survival.

Table 7: Biodiversity indicators								
Indicator	**Source / Organization**	**Countries**	**Objective**	**Measurement unit**	**Smallest spatial scale**	**# of locations**	**Time period**	**Frequency**
Number of threatened/ extinct species	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	number of species known and % threatened by class (mammals, birds, fish, reptiles, amphibians, vascular plants)	national	n/a	most recently available	unknown
Wetlands	US Fish and Wildlife Service, US Department of Agriculture OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	United States	none	total area (acres)	national	unknown	1950s–1990s	unknown
Protected areas	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	number of sites, total size (km^2/1000 inhabitants), area as % of national territory	national	n/a	1996	unknown

E. Aggregate Indicators

The various components of the ambient environment specified above are interrelated in complex ways. As the overall state and sustainability of entire ecosystems ate the ultimate concern of analysis, it is important to include more inclusive, "aggregate impact" indicators. Such indicators measure how change in a specific component of the ambient environment affects the natural ecosystem, human health, the economy, or society-at-large.

Such aggregate impact indicators or indices consist of two or more indicators. The greatest advantage of an index is its ability to collapse the data contained in two or more indicators into a single number and thus reduce the need for multiple indicators. A disadvantage of an index is that it can hide the contribution of each individual indicator contained within it. For example, one indicator in an index might be very negative while the remaining indicators are very positive. They thus produce an index number that is positive, but that conceals the fact that one component indicates a problem. Another concern in developing indices is the need to weigh and standardize indicators reporting different units when aggregating them into a single number. Different standardization methods can produce different index values, as can different weightings of the relative importance of the individual indicators.

All indicators reflect pressures, states, or responses in an ambient environmental medium. It is useful to include indicators that embrace change in more than one environmental medium, or that integrate more directly the interactions among economic, social and environmental processes, since they often reflect, at least indirectly, the linkage processes that lie behind them.

Integrative indicators are particularly difficult to develop, given the current need for much stronger theory to substantiate them. Some, such as photosynthetic balance, while conceptually appealing, remain difficult to apply in practice. On the other hand, in the case of several indicators, promising progress has been made. For example, there is sufficient theoretical development and empirical research to warrant the inclusion of "costs of environmental remediation" as an integrative and embracive indicator here. The same is true for the "ecological footprint," an indicator that measures the impact of human consumption activities on air, water, land and biota. A now widely used integrative indicator is "energy intensity," which measures energy consumed (and, by implication, pollution generated) by different approaches in production, management, technology and transportation across an entire economy.

The ten aggregate indices and embracive or integrative indicators identified in this section avoid many of the pitfalls of index construction by aggregating only those indicators that are measured in the same units. The indices include one for climate change, one for ozone depletion, one for eutrophication, one of acidification and one for the costs of environmental remediation. These indicators tend to be readily applicable. Four of these indices are being used on a regular basis in the Netherlands for monitoring the performance of its 1989 National Environmental Policy Plan. This plan and the monitoring program associated with it have received worldwide attention as an example of environmental performance monitoring (KPMG Milieu and TVA-Tilburg 1993).

The ten aggregate indicators or indices for general analysis are outlined below.

1. ***Climate change.*** A commonly-used pressure index relevant for climate change is total greenhouse gas emissions. The index is the weighted summation of five gases that contribute to global warming: carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NO_x), chlorofluorocarbons (CFCs) and halons. The theoretical foundation for the weights used in the index is strong, since the weights are based on the global warming potential (GWP) of each gas. One tonne of carbon dioxide has a GWP of 1 while the other gases are known to be larger contributors to global warming, per unit weight. For example, over a 100-year period, the GWP of methane is 11 times greater than carbon dioxide while that of CFC-12 is 7,100 times greater. Multiplying the annual emissions of each gas by its GWP transforms the emissions into carbon dioxide equivalents (Ceq) and then these amounts are summed across the gases to produce the index.

2. ***Ozone depletion.*** Stratospheric ozone shields human and other organisms from harmful ultraviolet (UV) radiation. Excessive exposure to UV radiation causes skin cancer, cataracts and immunosuppressive diseases in humans and animals. It also causes degradation of materials, such as rubber, wood and plastics, and slows plant growth. The damage to the ozone layer caused by CFCs, halons and other ozone-depleting gases depends on their residence time in the atmosphere and the rapidity with which they contribute to the destruction of ozone. These two factors determine the ozone depletion potential (ODP) of ozone-depleting gases. An ozone depletion pressure index can be formed by multiplying the emissions of CFCs and halons individually times their ODP and then summing the products. Since generation—or the atmospheric liberation (in the case of CFCs)—of these substances is assumed to be correlated with emissions, and since production data is usually more readily available than emissions data, a more accurate estimate can be achieved by using production rather than emissions data in the index. Indicator weights deriving from the ODP have scientific backing, and therefore overcome the subjectivity inherent in the weights found in many types of environmental indices.

3. ***Acidification.*** The three main acid gases incorporated in this index of acidification are sulfur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). The contribution of each gas to the acidification of atmospheric water vapor or surface lakes and rivers is weighted by its acidic potential and expressed in acidification equivalents.

4. ***Eutrophication.*** Two major contributions to the eutrophication of water bodies are nitrates and phosphates. This index aggregates emissions of nitrogen and phosphorus using a weighting scheme that accounts for their potential eutrophication effect.

5. ***Cost of environmental remediation.*** The cost of environmental remediation refers to the cost of cleaning up polluted or degraded environments and reducing pollution generated by human activity. Examples of remediation include building sewage treatment plants, cleaning up contaminated soil, installing pollution control devices in industrial plants, and replanting forests. This index is particularly attractive because it combines measures of the economy (including production, management and technology, physical infrastructure, social organization and government policy) and the environment.

6. ***Ecological footprint.*** Although extremely complex to apply, this index is useful, as it produces results that are easy to visualize. It estimates the total land area needed to

produce all of the resources consumed by the population of a specific geographic unit (e.g., a city or country) and to assimilate the wastes discharged by that population.

7. ***Energy intensity.*** Greater efficiency in energy production and use reduces environmental stress. This indicator also combines measures of the economy and the environment, and does so from a preventative rather than remedial perspective.

8. ***Human health costs of environmental pollution.*** Polluted air, water and land result in quantifiable hospital and health care costs from the illnesses they cause, which can be calculated and used as an indicator.

9. ***Energy mix*** (by source: coal, oil, gas, nuclear, hydro, other). This component of production is important because higher reliance on fossil fuels in the energy mix is associated with more severe local and regional air quality problems and with greater production of greenhouse gas emissions.

10. ***Biological integrity.*** This index can reflect the cumulative effect of a wide variety of chemical and physical stressors on natural ecosystems, and the extent to which the ecosystem supports healthy biological communities.

Table 8: Aggregate indicators

Indicators	Source / Organization	Countries	Objective	Measurement Unit	Smallest Spatial Scale	# of Locations	Time Period	Frequency
Greenhouse gas emissions (CH4, CFCs, NO_x, CO_2)	Environment Canada, Pollution Data Branch www.ec.gc.ca/pdb/pdb_e.html	Canada	none	tonnes CH_4 by source, CO_2-equivalents by source	national	n/a	1990–94	annual
	OECD Environmental Compendium: 1997	Canada, United States, Mexico	stabilize emissions by 2000 at 1990 levels	total annual emissions (tonnes)	national	n/a	1995	unknown
CFC consumption (including halons and HCFCs)	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico, industrial-ized countries	CFCs and halons—zero production and consumption, phase out supply of HCFCs and methyl bromide by 2005	tonnes, % change since 1986, kg per capita	national	n/a	1986–95	unknown
CFC production (including halons and HCFCs)	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico, industrial-ized countries	CFCs and halons—zero production and consumption, phase out supply of HCFCs and methyl bromide by 2005	tonnes, % change since 1986	national	n/a	1986–95	unknown
Energy intensity	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	compared to 1980 level, energy supply and GDP	national	n/a	1980–95	unknown
Energy mix (by source: coal, oil, gas, nuclear, hydro, other)	OECD *Towards Sustainable Development: Environmental Indicators* (1998) (update of the 1991 core set)	Canada, United States, Mexico	none	total, % change since 1980, structure by source (share of total)	national	n/a	1980–95	unknown
Biological Integrity	US EPA, Office of Water *Environmental Indicators of Water Quality in the United States* (June 1996)	United States	none	tons per year	state	31	1992–94	annual

F. Selection Criteria for Sector-Specific Indicators

In addition to referring to the common indicators of ambient and aggregate environmental quality detailed above, sectoral or issue studies on the environmental effects of NAFTA will need to investigate and develop indicators that describe sector- or issue-specific effects in more detail. One consideration in the selection of these additional indicators is to seek a balance of pressure, state and response indicators. Another consideration is to narrow down the range of possible indicators to a manageable set. The remainder of this section presents several selection criteria that may be useful for deciding which indicators to include in that set.

The selection criteria are drawn from a variety of sources describing criteria for selecting environmental and sustainability indicators (Corvalán et al. 1997, Environment Canada 1994, Forrest and Morrison 1991, Gallopin 1997, Liverman et al. 1988, Maclaren 1996, OECD 1994, and Pocock 1981). The inclusion of sustainability selection criteria is relevant because sustainability indicators always comprise at least some environmental indicators.

The ten selection criteria most commonly cited in the literature are as follows:

1. ***Scientific validity.*** This criterion normally refers to the validity of the indicator with regard to the system, issue, or environmental medium being described. Demonstrating the existence and strength of the link between a pressure indicator and the state to which it applies (e.g., the link between pesticide use in agriculture and water quality) is important in evaluating its scientific validity. Likewise, for a state indicator, the validity assessment could focus on showing the link between the state and a particular issue (e.g., between CO_2 concentrations in the atmosphere and global warming). Alternatively, a judgment about the scientific validity of a state indicator might rest on the significant impacts of that indicator (e.g., the significance of dioxin as a known carcinogen). Assessing the validity of a response indicator might involve showing how the policy response can, in fact, reduce the level of a pressure indicator or improve the state indicator.

   In some cases, the scientific validity of an indicator is self-evident or can be deduced logically, and does not need empirical support (e.g., the pressure indicator, amount of waste sent to landfill, is clearly linked to the state indicator, amount of landfill capacity remaining). Scientific validity can also refer to the validity of the measurement units being used. For example, total car ownership by residents in a city is an inadequate parameter for measuring air quality in that city as affected by automobile use. Arriving at the indicator in this way excludes the contribution of cars driven by commuters from outside the city and ignores the fact that many people who own cars in the city may use other modes of transportation, particularly in the city's inner core.

2. ***Representativeness.*** This criterion deals with the breadth of pressures, states or responses covered by an indicator. A consideration of this is important because of the

cost and time involved in collecting data for a very large number of indicators. Using a single representative indicator cuts down on these costs. A common example of a representative indicator is fecal coliform, which is known to be correlated with a number of other biological contaminants of water. The distinction between representativeness and scientific validity is that a representative indicator correlates with other indicators within a particular category of indicators (i.e., a representative pressure indicator correlates with other pressure indicators) whereas a scientifically valid indicator often refers to the correlation of an indicator across indicator categories (i.e., the correlation of a pressure indicator with a relevant state indicator).

3. ***Responsiveness.*** A responsive indicator should exhibit detectable changes during the period of analysis and respond to external stimuli, such as policy interventions.

4. ***Early warning capability.*** Some indicators can provide early warning of future environmental problems because they anticipate changes in pressure or state indicators. For example, changes in the ozone layer typically lag several years behind changes in the emissions of ozone-depleting substances. Therefore, increased emissions of ozone-depleting substances can provide an early warning of future deterioration in the ozone layer.

5. ***Data availability, accuracy and accessibility.*** In practice, data availability may be the single most important constraint on the selection of indicators. Over the longer term, this is less a problem since the indicator development process can identify and recommend areas where future data collection will be needed. Indicators that have sufficient data to show trends over time are most preferred. Data accuracy refers to the necessity for collecting data that are free of errors. Data accessibility refers to situations in which data are being collected but are not accessible to the public.

6. ***Intelligibility.*** The meaning of an indicator should be comprehensible to the target audience. Almost any indicator can be made comprehensible with accompanying text explaining the meaning, but the impact of an indicator may not be as great if the audience has difficulty understanding completely new or complex information.

7. ***Comparability to reference points.*** Typical reference points include targets, thresholds, regulatory standards, and national averages. The ability to compare an indicator to reference points is an effective method for measuring progress toward stated goals, and is therefore meaningful from a policy perspective. When using reference points in a comparative context, it is important to remember that different jurisdictions may employ different reference points for the same indicator.

8. ***Comparability with indicators developed in other jurisdictions.*** For the purposes of monitoring the environmental effects of NAFTA, the most desirable indicators, at least initially, will be those for which data and reporting systems already exist or are being created in all three member countries. These indicators will facilitate continent-wide

analysis of environmental effects. Over time, as data gaps are identified, the availability of comparable indicators should increase.

9. ***Cost-effectiveness.*** The cost of collecting data may be a consideration in choosing among potential indicators. For some types of data, it may be possible to reduce costs in the longer term by encouraging the growth of community-based monitoring programs or by using remote sensing data.

10. ***Unambiguity.*** There should be general agreement about the meaning—positive or negative—of an increase in the level of an indicator. For example, one potentially ambiguous indicator is urban density. Empirical research has shown that higher urban densities are associated with reduced gasoline consumption per capita (Newman and Kenworthy 1988) and are therefore preferred over lower urban densities. On the other hand, research has also shown that higher densities bring negative environmental effects (Gordon and Richardson 1989). Some argue that ambiguity is a desirable characteristic because it can stimulate debate about the message being sent by the indicator. Most experts agree, however, that such debate usually reflects the indicator's lack of utility.

Appendix: Foreign Direct Investment Trends under NAFTA

This appendix explores the patterns of foreign direct investment, and related foreign portfolio investments, that have taken place in North America during the 1990s. It assesses the extent and ways in which changes in the flow, stock and other aspects of this investment are associated with NAFTA. It also identifies, where possible, the environmental incentives these changes in investment have created, and the environmental impacts they have had.

In undertaking this analysis, it is important to recognize that as soon as the negotiation of NAFTA started in 1991, investors assumed that the agreement would be approved by the legislative powers of the three countries. Therefore, investments made during the years 1991–94 can be considered as related to NAFTA. They are largely explained by the prospect of the agreement and the enlarged regional markets expected from it. Investors from within the region would be at an advantage over those from without, as they would enjoy a more favorable trade regime and guarantees over market access not extended to others from outside.

Similarly, the prospect of NAFTA also limited all new investments to those that could be competitive in such a regime. This involved both the need for technical efficiency and the need for firms to meet minimum standards of quality, and labor and environmental performance.

For these reasons, most of the flows of FDI as the NAFTA negotiations started were the result of strategic corporate decisions. Firms wanted to take positions in a market expected to grow under the benefits of a new trade and investment regime. The new regime assured them of a continued reduction in trade tariffs and, more significantly, it relaxed some restrictions for investing in another country of the region. The latter included enhanced security to investors in case of disputes with the host government and the important principle of "national treatment," alluded to above. This principle compels governments to view investors from the partner countries as being no different from domestic investors. It thus rejects discrimination on the basis of national origin.

An analysis in 1996 indicated that in NAFTA's first few years in operation, Mexico was the country that recorded the greatest impact from this change of regime (Ramirez de la O. 1996a). Not only did the flow of FDI increase, but the new investment was also based on more modern technologies than existed in most of the equivalent domestic industries.

In assessing NAFTA's effects over a longer period, it is important to begin with a recognition that the largest flows of FDI in the world originate in the United States. Indeed, the global trends in FDI stem largely from the trends in US outward-directed FDI. The United States is also the largest recipient of flows of FDI from the rest of the world. Flows to the United States have increased rapidly since the late 1980s, through the start of NAFTA, and have continued to rise in recent years. The book value of the stock of FDI in the United States grew by 173 percent between 1985 and 1994 while that of US FDI in the rest of the world grew by 167 percent. This is indicated in Table A-1.

Table A-1: FDI from the rest of the world to the United States and from the United States to the rest of the world, 1985–97 (billions of US$)

	Investment into the United States		Investment from the United States	
YEAR	**FLOW**	**STOCK***	**FLOW**	**STOCK***
1985	20.0	184.6	16.8	229.7
1986	35.8	220.4	29.8	259.5
1987	41.5	261.9	49.2	308.7
1988	67.0	328.9	25.0	333.7
1989	44.9	373.8	36.3	370.0
1990	22.9	396.7	54.0	424.0
1991	17.7	414.4	36.9	460.9
1992	5.1	419.5	42.0	502.9
1993	44.6	464.1	57.6	560.5
1994	40.3	504.4	52.4	612.9
1995	56.4	560.8	86.1	699.0
1996	69.2	630.0	78.2	777.2
1997	51.6	681.6	83.5	860.7
Annual Average, Pre-NAFTA				
1985–90	**38.7**	**294.4**	**35.2**	**320.9**
Annual Average, Post-NAFTA				
1991–94	**26.9**	**450.6**	**47.2**	**534.3**
1995–97	**59.1**	**624.1**	**82.6**	**779.0**

Both Mexico and Canada represent a small share of the FDI to and from the United States, despite the rapid expansion seen in recent years. The stock of FDI originating in the US and directed to Mexico more than doubled between the second half of the 1980s and the NAFTA period (1991–94). From 1985 to 1994, it jumped 221 percent, substantially more rapidly than total US FDI in the world. On average, the stock of US FDI in Mexico was US$6.2 billion per year between 1985 and 1990, prior to NAFTA, and more than double that (US$14.3 billion) during the first phase of NAFTA between 1991 and 1994. This is a large increase, especially considering that the book value often results in under-estimating the investment.

At the same time, the stock of US FDI in Canada grew by only 55 percent. This lower growth is explained by the pre-existing large representation of Canada in total US FDI. It is also explained by the recession of 1992, which resulted in a negative inflow that year and in weak inflows during the surrounding years. Canada and the United States had signed a Free Trade Agreement in 1989, preceded by an auto industry pact in 1965. Both encouraged investment flows prior to NAFTA. In addition, Canada has been a traditional destination for US FDI, given the size of its market, its geographic proximity, and the similar economic regimes of the two countries. Canada's share of US FDI increased from $47.1 billion to $72.9 billion between 1985 and 1994. However, this represented a decline from 20.5 to 11.9 percent in terms of total US FDI, as indicated in Table A-2.

Table A-2: Stocks and flows of US FDI, 1985–97 (billions of US$ or % of total)										
	Stock (book value)					Flows				
YEAR	All Nations	In Mexico	% of Total	In Canada	% of total	All nations	In Mexico	% of Total	In Canada	% of Total
1985	229.7	5.1	2.2	47.1	20.5	16.8	0.5	3.0	0.3	1.8
1986	259.5	4.8	1.8	50.0	19.3	29.8	-0.3	-1.0	2.9	9.7
1987	308.7	5.0	1.6	56.9	18.4	49.2	0.2	0.4	6.9	14.0
1988	333.7	5.7	1.7	62.0	18.6	25.0	0.7	2.8	5.1	20.4
1989	370.0	7.3	2.0	66.8	18.1	36.3	1.6	4.4	4.8	13.2
1990	424.0	9.4	2.2	67.0	15.8	54.0	2.1	3.9	0.2	0.4
1991	460.9	12.2	2.6	68.8	14.9	36.9	2.8	7.6	1.8	4.9
1992	502.9	13.3	2.6	68.4	13.6	42.0	1.1	2.6	-0.4	-1.0
1993	560.9	15.2	2.7	69.0	12.3	57.6	1.9	3.3	1.2	2.1
1994	612.9	16.4	2.7	72.9	11.9	52.4	1.2	2.3	3.2	6.1
1995	699.0	15.6	2.2	83.2	11.9	86.1	-0.8	-0.9	10.4	12.1
1996	777.2	19.9	2.6	91.3	11.7	78.2	4.3	5.5	8.1	10.4
1997	860.7	25.4	3.0	99.8	11.6	83.5	5.5	6.6	8.5	10.2
Annual average, pre-NAFTA										
1985–90		**6.2**	**1.9**	**58.3**	**18.4**	**35.2**	**0.8**	**2.2**	**3.4**	**9.9**
Annual average, post-NAFTA										
1991-94		**14.3**	**2.7**	**69.8**	**13.2**	**47.2**	**1.8**	**3.9**	**1.5**	**3.0**
1995-97		**20.3**	**2.6**	**91.4**	**11.7**	**82.6**	**3.0**	**3.7**	**9.0**	**10.9**

Source: US Department of Commerce, *Survey of Current Business, 1986–88*

The Canadian economy is closely integrated in many ways with that of the US. Thus, Canada's relative decline as a recipient of US FDI should not be interpreted as a reversal of this integration or a loss of interest on the part of US investors. The rapid expansion of US FDI in other regions of the world responds to dynamic changes in economies that were previously not so attractive or so open to US investors. Thus, Asia and Eastern Europe attracted large inflows from the United States, as investors sought to position themselves in economies that had great potential for modernization and market growth. Similarly, the process of European integration attracted a new wave of FDI, most of it originating in the United States.

Thus, while Canada's relative share of US FDI has fallen, its continued increase—especially after 1994—indicates growing integration of the two economies. By the same token, Mexico's small increase in total US FDI, from 2.2 percent of the total in 1985 to 2.7 percent in 1994, masks its increasing importance to US investors.

Accelerated flows of FDI after NAFTA

NAFTA went into effect in 1994. This coincided with a large increase of FDI from the United States to both Canada and Mexico. Similarly, Canadian FDI experienced considerable growth—both in the United States and Mexico. On the other hand, Mexican FDI in the United States peaked in 1994 and continued to be negligible in Canada. (The contraction of Mexican FDI in the United States is explained by the negative outcome of some large investments made prior to NAFTA by Mexican firms in that market. The losses, and eventually the disposal of US assets by Mexican investors, explain the contraction, as will be discussed further, below.)

The large increase in the stock of US investment in Mexico and in Canada coincided with a large increase in world investment into the United States and of US investment in the rest of the world. The stock of US FDI in Canada increased by a large US$26 billion between 1994 and 1997. This means that Canada received 10.5 percent of the increased flow in total US FDI—a global FDI stock totaling US$248 billion. The increase of US FDI in Mexico was similarly very high at US$9 billion, or 3.6 percent of the US global total. Taken together, the two NAFTA partners thus accounted for 14.1 percent of the increase in the US global stock of outward FDI from 1994–97.

Thus, although FDI in North America during the NAFTA phase has been impressive and—in the case of Mexico—large relative to its share in the period prior to NAFTA, it was part of a global trend. Mexico has seen the percentage of its share of the total US flows increase from 1.2 percent of total US outflows in 1994 to 3.0 percent in 1997, but the figure is still too small to carry any definitive meaning. Although NAFTA has been a major motivation for the expansion of FDI in the region, it is still not certain that it exerts any extraordinary influence beyond that indicated by global trends. NAFTA has been, however, a vehicle of increasing economic integration in North America and this has enabled Mexico and Canada to maintain a position in the global flows of FDI.

Leading sectors in global FDI

In the expansion of US FDI between 1985 and 1997, the leading investments were in the financial sector. This sector experienced the largest relative increase, from 7.4 percent of the stock of US FDI to 32.3 percent in 1997. This increase also explains why the manufacturing industry's share of the US FDI stock has declined from 40.6 percent to 33.2 percent over the same period. However, manufacturing continues to be the largest individual recipient of US flows, as indicated in Table A-3.

By contrast, in global FDI directed to the United States, the share of manufacturing, which continues to be the largest, grew from 31.5 percent of the total to 39.2 percent during the same period. In the case of foreign investment in the United States, investment in finance has expanded less than it has expanded for outflows of US investment in the same sector. This highlights not only the strength of US financial industries relative to that of foreign financial industries, but also the liberalization of financial sectors in many countries in which foreign investors could not participate before the 1990s. This is shown in Table A-4.

Table A-3: Stocks* of US FDI in the world by sector, 1984–97 (billions of US$)														
Pre-NAFTA								**NAFTA period**						
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
All industries	211.5	230.2	259.8	308.0	326.9	381.8	427.0	461.0	502.1	559.7	612.1	717.6	777.2	870.7
Petroleum	58.0	57.7	58.8	61.8	59.6	48.3	52.8	55.9	58.5	63.5	65.7	70.2	74.5	85.7
Manufacturing	85.9	94.7	105.1	127.1	133.8	147.9	158.0	180.5	186.3	194.3	220.3	250.2	272.2	288.9
Whole trade	21.1	22.8	26.2	31.4	34.4	38.4	43.1	47.9	52.7	57.1	67.3	67.2	69.6	69.1
Banking	13.5	14.5	14.5	15.2	16.1	19.4	20.7	21.2	24.7	27.1	29.5	28.1	33.7	34.4
Finance**	15.7	22.5	36.4	52	60.6	101.1	109.4	118.0	137.2	169.0	175.0	228.7	241	280.9
Services	4.4	4.7	5.1	6.4	7.1	11.7	13.1	15.4	17.2	19.7	23.0	32.8	35.79	40.9
Other Industries	12.8	13.4	13.9	14.1	15.2	14.8	19.9	22.2	25.5	29.0	31.2	40.2	50.38	61.5

*At book value; **Includes insurance and real estate
Source: US Department of Commerce, *Survey of Current Business, 1984–98*

Table A-4: Stocks* of world FDI in the US by sector, 1984–97 (billions of US$)

	Pre-NAFTA							NAFTA period						
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
All industries	164.6	184.6	220.4	328.8	314.8	368.9	394.9	419.1	427.6	464.1	504.4	560.9	594.1	681.7
Petroleum	25.4	28.3	29.1	35.6	36.0	40.3	42.8	40.0	37.6	31.7	34.0	33.9	43.8	47.7
Manufacturing	51.8	59.6	72.0	64.7	122.6	150.9	152.8	157.1	158.9	166.4	184.5	213.0	242.3	267.1
Wholesale trade	24.4	29.0	34.0	39.8	43.7	45.4	50.9	56.9	57.5	60.6	65.8	79.1	75.1	87.6
Retail trade	6.8	6.8	8.9	10.2	9.9	8.5	9.2	8.4	10.4	12.2	13.8	n/a	13.7	16.1
Banking	10.3	11.4	12.4	14.4	16.9	18.4	18.4	24.9	28.4	33.5	36.7	34.1	32.2	37.1
Finance	5.6	4.2	7.2	3.8	8.1	18.6	8.3	11.4	12.9	34.4	34.7	62.4	37.7	42.5
Insurance	8.9	11.8	15.3	17.4	19.0	22.5	27.1	33.3	35.8	40.4	41.4	51.0	54.7	69.1
Real estate	17.8	19.4	22.5	27.5	25.9	30.4	34.9	33.6	32.4	28.4	28.4	29.7	33.2	34.1
Services	2.5	2.9	6.7	13.6	19.0	20.6	30.59	34.4	35.4	34.8	36.5	n/a	32.4	45.6
Other industries	7.1	7.1	7.1	8.9	13.6	13.0	19.6	19.0	18.3	21.7	28.6	57.7	29.1	34.8

*At book value; n/a: not available
Source: US Department of Commerce, *Survey of Current Business, 1984–98*

Similarly, FDI in services has experienced rapid growth, both into and out of the United States. The expansion of world foreign investment in US services since the late 1980s underlines the increasing importance of this sector for US economic activity. By contrast, US investments in services in the rest of the world appear to be more closely related to the liberalization of that sector in Europe, Asia and Latin America, which took place during the early 1990s. This was particularly the case in telecommunications, where US investment has been prominent.

Large share of manufacturing in FDI in North America

The FDI trends by sector in North America are similar to those observed in global FDI. Some distinctions, however, must be highlighted. In US FDI in Canada, the manufacturing industry has maintained a large representation, increasing from 44.8 percent to 46.0 percent of the total stock of US FDI in Canada between 1984 and 1997. This was despite the large increase in the share of finance (similar to that observed in global US FDI) from 13.1 percent to 19.0 percent during the same period. Thus, FDI from the United States to Canada is largely focused on the manufacturing industry. This is to be expected from the high economic integration between the two countries, an integration that involves joint production plants located in the United States and in Canada under the same ownership. This started with the automotive industry, but has now expanded to other industries. This is shown in Table A-5.

Table A-5: Stocks* of US FDI in Canada by sector, 1984–97 (billions of US$)

	Pre-NAFTA							NAFTA period						
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
All industries	46.4	47.2	50.0	56.9	70.7	65.7	67.0	68.9	68.5	69.7	72.9	85.4	91.3	99.8
Petroleum	11.2	10.5	10.9	11.9	11.7	10.7	11.4	9.7	8.0	8.7	8.6	10.4	11.3	12.7
Manufacuturing	20.8	21.9	25.4	25.8	38.9	31.6	31.8	31.8	33.3	33.6	35	42.2	42.2	45.9
Wholesale trade	2.4	2.5	2.6	3.2	3.5	3.9	4.1	5.5	5.6	6.9	7.0	7.2	7.9	7.3
Banking	0.5	0.5	0.6	0.6	0.8	1.0	1.0	1.1	0.9	0.8	0.8	0.9	1.0	1.0
Finance**	6.1	5.8	6.4	8.9	10.9	11.7	11.4	12.9	12.9	11.1	12.2	14.3	16.8	19
Services	0.7	0.8	0.9	0.9	1.3	1.3	1.9	2.5	2.3	3.2	3.5	4.0	4.1	4.7
Other industries	4.7	5.2	5.2	5.6	3.6	5.5	5.4	5.4	5.5	5.4	5.8	6.4	7.9	9.2

*At book value; n/a: not available
Source: US Department of Commerce, *Survey of Current Business, 1984–98*

Manufacturing investment drew a very large proportion—79.5 percent—of the total stock of US FDI in Mexico in 1984. This is shown in Table A-6. This was largely because Mexico had restricted foreign investment in many other areas, particularly in finance and some services, where global FDI was growing rapidly. The reduction observed in manufacturing in Table A-6 from 79.5 percent in 1984 to 59.5 percent in 1997 took place despite a five-fold increase in the stock of FDI from $3.6 billion to $15.1 billion. In other words, given the large, untapped opportunities for FDI in Mexico in service industries and

finance, it is difficult to attribute the relative reduction in the flows for manufacturing to a gradual loss of interest of investors in this industry.

NAFTA appears to have been a major motivation for investment in many manufacturing firms. This was evident from interviews with investors since 1996 (Ramirez de la O. 1996a). Table A-6 shows that the stock of US FDI more than trebled between 1988 and 1997, while the stock in finance went from zero to $4.1 billion in the same period. Investment participation by US investors in finance in Mexico have included insurance, stock-brokerage houses, investment banking, and other financial services, although investment in banking remains poor.

Table A-6: Stocks† of US FDI in Mexico by sector, 1984–97 (millions of US$)

	Pre-NAFTA							NAFTA period						
	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
All industries	4,568	5,070	4,750	1,997	5,694	7,280	9,398	12257	13350	15229	16,375	15,980	19,900	25,395
Petroleum	75	52	42	65	60	79	80	(*)	(*)	(*)	(*)	134	84	109
Manufacturing	3,632	4,073	3,775	3,959	4,776	5,853	7,196	8,778	9,281	9,349	10,697	9,843	12,407	15,119
Wholesale trade	410	522	647	277	351	480	508	704	777	872	994	783	826	862
Banking	0	0	(*)	(*)	(*)	(*)	39	(*)	(*)	(*)	(*)	299	442	510
Finance**	194	184	158	198	0	242	400	659	798	2,045	1,982	2,263	2,873	4,079
Services	(*)	-16	129	147	101	128	149	32	325	250	261	368	685	924
Other industries	261	257	(*)	(*)	(*)	(*)	1,025	1,647	1,935	2,419	2,335	2,289	2,583	3,792

Note: The sum of the parts may be less than the total in all industries because of omission of minor values
†At book value; (*) Less than $0.5 million; **Includes insurance and real estate
Source: US Department of Commerce, *Survey of Current Business, 1984–98*

The Mexican banking sector, as is the case in Canada, has recorded very small FDI inflows. This is due to the restrictions imposed by the Mexican government on foreign ownership in banking. This situation was exacerbated by the banking crisis that started in the early 1990s and continued into the late 1990s. Though Mexico has now lifted most of the former restrictions, foreign investment in banking is inhibited. This is due to continued problems of insufficient capitalization of all Mexican banks.

Canadian and Mexican FDI

Canadian data on FDI have not been available in the same degree of detail as US data for the period after 1994, while Mexican data show large discrepancies with US data. These discrepancies are probably caused by the use of different valuation criteria. For that reason, data of these two countries are only used here to further discuss basic trends found with US data.

Table A-7 shows the stocks of Canadian and Mexican FDI in the United States. The Canadian series indicates that between 1990 and 1994 its stock rose by $10.5 billion. The stock of Canadian FDI in the United States (according to the US series), however, jumped during the same period by $13.7 billion.

Table A-7: Mexican FDI in the United States, 1985–97 (billions of US$)

	Pre- NAFTA						NAFTA period							Annual average, pre-NAFTA	Annual average, post-NAFTA
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**		
Stock*	0.5	0.8	0.9	0.8	1.2	0.6	0.7	0.8	1.2	2.2	2.0	1.4	1.7	0.8	1.4
Flows	0.2	0.3	0.3	-0.1	0.4	-0.6	0.1	0.1	0.4	1.0	-0.3	-0.6	0.3	0.1	0.1

Canadian FDI in the United States, 1985–97 (billions of US$)

	Pre-NAFTA						NAFTA period							Annual average, pre-NAFTA	Annual average, post-NAFTA
	1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**		
Stock*	17.1	20.3	24.0	26.6	30.4	29.5	36.8	37.8	40.1	43.2	48.2	54.8	64.0	24.7	46.4
Flows	1.8	3.2	3.7	2.6	3.8	-0.9	7.3	1.0	2.3	3.1	5.0	6.6	9.2	2.4	4.9

* At book value
Source: US Department of Commerce, *Survey of Current Business*, 1986–98

After 1994, the stock of Canadian investment in the United States continued to rise from $43 billion to $64 billion by 1997, according to US data, with the flows recovering from the low levels recorded during the US recession of 1992.

Mexico has been recording a large increase in the inflows of Canadian FDI. Despite the large percentage increase; however, such investments are very small. They totaled only $1.8 billion in 1997, according to Mexican sources. Originally, until the mid-1980s, Canadian investment in Mexico was concentrated in mining, machinery, and electrical cables, but this investment did not

show great momentum. Later, in the early 1990s, Canadian investment was attracted to Mexican banking, with three Canadian banks taking minority stakes in Mexican banks. The implementation of NAFTA also attracted Canadian investment in telecommunications equipment. These investments grew at a fast pace, but they started from a very low base. Overall, therefore, Mexico has attracted only a small amount of Canadian FDI. NAFTA has encouraged Canadian direct investment in Mexico in banking, telecommunications and auto parts, but this has not been spread uniformly across all sectors.

Mexican outflows of FDI have always been very small and almost exclusively concentrated in the United States. This is largely a consequence of the sectors in which Mexican firms have a comparative advantage. Such sectors are related to large-scale industrial materials such as chemicals, cement, glass and textiles. To a lesser degree, some investments relate to processed foods and beverages.

During the early NAFTA period (1991–94), when Mexico benefited from a strong peso and artificially cheap credit, the outflows of FDI from Mexico to the United States increased. This coincided with a time of weakness in some US industrial sectors. Large Mexican firms who had liquid resources ventured for the first time into such sectors of US industry, in anticipation of a growing integration of the two economies. The increase in Mexican FDI in the United States reached a peak of $2.2 billion in 1994. By that time this stock also included some small banks in California and Texas bought by Mexican investors, a large firm of preserved fruits and vegetables, a newspaper and a US cable TV company.

The peso crisis of 1994, followed by a long period of scarce liquidity, high interest rates and deteriorating bank portfolios in Mexico resulted in sales of Mexican assets in the United States. The stock of Mexican FDI thus declined after 1994, although it is still well above the level recorded during years prior to NAFTA.

Employment and Exports of US FDI

Data on employment and trade generated by firms with foreign direct investment are available only for US outflows, not for Mexican or Canadian FDI abroad. An analysis in 1996 (see Table A-8) showed that in 1993, Mexico accounted for 3.2 percent of all assets of US direct investors abroad, but 11.7 percent of total US exports to affiliates of US investors abroad and 10.0 percent of their employees (Ramirez de la O. 1996a). US FDI in Mexico was thus highly export- and employment-intensive.

US FDI to Canada in 1993 was responsible for a slightly higher percentage of employees (13.1 percent), but a much higher share of total assets (11.7 percent) and even higher share of exports to US affiliates (36.5 percent). In the cases of both Canada and Mexico, those percentage shares rose until 1993. This underlines the strong link between investment and trade in North America.

Table A-8 shows further that employment by US direct investors in both countries continued its rise to 1996. In Mexico, this added 68,000 workers between 1993 and 1996, to reach 733,900 workers in the latter year. This is a noticeable increase, in light of the heavy recession suffered in Mexico, which caused a fall in total employment of about one million workers in 1995.

Table A-8: US FDI in Canada and Mexico: Assets, exports and employment, 1992–96 (billions of US$)

Mexico						
Year	**Total US assets**	**% of US total**	**US exports to affiliates***	**% of US total**	**Employees**	**% of US total**
1992	47.1	2.7	13.2	10.8	660,300	9.9
1993	56.6	3.2	14.3	11.7	666,100	10.0
1994	57.5	2.4	16.7	10.5	735,300	10.3
1995	59.4	2.1	17.2	9.7	746,100	10.2
1996	67.4	2.2	21.2	10.9	733,900	9.6
Canada						
Year	**Total US assets**	**% of US total**	**US exports to affiliates***	**% of US total**	**Employees**	**% of US total**
1992	193.9	11.0	42.0	34.4	870,000	13.1
1993	205.8	11.7	44.6	36.5	874,900	13.1
1994	224.0	9.4	56.8	35.6	891,800	12.6
1995	251.9	8.9	D	--	925,500	12.6
1996	276.6	9.0	61.1	31.5	921,800	12.1

* Affiliates of US firms in the host country
Source: US Department of Commerce, *Survey of Current Business*, 1995–98

The figures of Table A-8 show no relapse in the employment generated by US investors. This is largely because of the increasing manufacturing activity in Mexico, much of it focused on exports, especially to the United States. Part of this activity is in maquiladoras, or processing assembly plants. Such plants have multiplied and their employment has too. However, they are not very different from other Mexican plants dedicated to export markets.

Moreover, under the NAFTA regime, maquiladoras are allowed to sell increasing percentages of output in the domestic market. Thus, convergence is taking place between maquiladoras, in the past exclusively dedicated to exports, and other firms that now have improved access to imported materials.

However, the recession of 1995 in Mexico still took its toll. This is reflected in the fact that employment did not keep increasing and actually fell as a percentage of total employment created by US firms abroad. The recovery that started in 1996 has continued so that the percentage share of Mexico in total employment is expected to rise again. The same correction in 1995 in US exports to US affiliates in Mexico is observed.

In Canada, a reduction in the shares of Canadian assets as a percentage of total US investments abroad is evident between 1992 and 1996. This is despite the large increase in the value of assets of US investors and in the value of US exports to the affiliates of US investors in Canada (rising from $42.0 billion in 1992 to $61.1 billion in 1996—see Table A-8).

Thus, although trade generated by US investors has been increasing in North America during the 1990s, it has not increased at a faster pace than trade with the rest of the world. Similarly, the value of assets of US investors in Canada and Mexico, though increasing over time, has not increased as fast as the value of total assets abroad. These patterns are explained in terms of the opening up of new opportunities for investment in other areas of the world.

The low value of assets of US investors in Mexico relative to the large number of workers employed is explained by the labor-intensive operations of maquiladoras. These plants are intensive assembly operations that require little in the way of fixed assets and constantly exchange products and parts with their US parent or sister companies across the border. Thus, although they are not capital-intensive operations, this does not imply low-quality production or technologically obsolete plants.

Indeed, maquiladoras on the northern Mexican border have become increasingly complex and technical in their operation. Some of these plants are in the third generation of their evolution from simple assembly of products to engineering and design functions. GM, the largest employer of maquiladoras, has used Mexico as a site for complex design works through its Delphi subsidiary. Similarly, the operations of other investors have become gradually more complex. Another example of this is Sony's state-of-the-art operation in Tijuana dedicated to the US market. Emerson Electric has increased its employment from 10,000 to nearly 18,000 employees in various plants located all over Mexico that assemble complex electronic control and measurement products. GE is undertaking a rapid transformation of its product mix in Mexican maquiladoras, switching from relatively simple products to more complex electronics and planning that will include software development.

Sectoral Destination of FDI in Mexico

The Mexican Ministry of Trade and Industry has identified the sectors to which FDI from the United States and Canada has been directed. Table A-9 shows that prior to NAFTA, between 1989 and 1990, FDI from the United States was $4.1 billion or about $2 billion per year. Of this, 26.8 percent ($1.1 billion) was directed to the manufacturing industry, mainly metallic goods and machinery. The auto industry is the largest in this sector and accounted for most of the inflows.

Table A-9: Main destination of US FDI in Mexico by sector, 1989–98 (accumulated inflows, billions of US$)

	1989–90	1991–94	1995–98
Total	4.1	11.5	19.8
Manufacturing	1.1	4.0	12.4
Processed food, beverages, tobacco	0.2	1.5	2.3
Textiles	0.0	0.4	n/a
Chemicals	0.3	0.6	0.7
Metallic goods, machinery	0.4	1.1	1.9
Trade	0.4	1.6	2.6
Finance	0.6	0.2	1.4
Real estate	1.2	0.5	0.1
Restaurants, hotels	0.4	1.2	0.3
Professional services	0.2	1.7	0.2

n/a: not available

Source: Mexican Ministry of Commerce and Industry

Investment in real estate was greater than that in manufacturing. The amount invested in manufacturing metallic goods and machinery (including autos) was matched by the amount of investment in trade and was exceeded by that in finance.

Between 1991 and 1994, during the early phase of the NAFTA period, the share of investment in manufacturing rose to 34.7 percent ($4 billion) of the total. The largest share was in processed foods followed by metallic goods and machinery. Investment rose in the professional services sector, as accounting, advertising, and public relations firms expanded in Mexico.

The large investment in food and beverages was directed mainly to beer, mineral bottled water, preserved foods and vegetables, alcoholic beverages, snacks and fast food stores. In most of these cases, the foreign investment took the form of a joint venture with Mexican investors, contributing funds that were used to increase manufacturing and export capacity. Much of this increase came through new plants that incorporated the latest technology, as efficiency was a major driving force in the strategies of investors. This was regarded as essential for the firms to compete in North American markets.

The investment in metallic goods and machinery was mainly for the auto industry, and it involved wholly-owned facilities by US investors. This investment was focused on upgrading and re-tooling the existing Mexican plants of auto firms. Such projects often entailed extensive adaptation and modernization of plants. This was also the case of engine plants, where US investors capitalized new engine models and more efficient production facilities and processes. The new models replaced older ones that had served in Mexico from the 1970s, produced mainly by state firms that had been privatized in the 1990s and their plants overhauled by the new owners. They included Dina, Cummins, and Mercedes Benz, producers of trucks and truck engines. The technology brought about by the new owners involved new models of engines, with considerably more efficient combustion, reduced noise and fewer emissions than those they replaced. The plants were re-tooled to render production runs more efficient and cleaner. All of them introduced new emission control equipment and made the environment a specific concern in plant operation.

A large share of the real estate investment shown in Table A-9 went to tourist resorts on the West Coast of Mexico, Baja California, and the Yucatán peninsula. These involved construction of resorts and development of infrastructure to provide water, electricity and sewage to areas that had been largely underdeveloped until then. Another portion of this investment went to the Santa Fe office and commercial development west of Mexico City.

The Santa Fe area had been for decades a site of garbage collection that caused substantial air pollution and contamination as the garbage was under intense sunlight and completely exposed to winds. The Mexico City Government started the cleaning and rehabilitation of this entire area in the late 1980s. The area is now a modern and clean site of office buildings and retail shops, with abundant use of space and green areas. Foreign investors from the United States, Canada and the United Kingdom took a major stake in this development.

In the second stage of NAFTA (post-1994), investment in manufacturing has seen its share increase to 63 percent of the US total. There is an even larger inflow accumulated for the period 1994–98, with $2.3 billion in foods and beverages and a higher amount in metallic goods and machinery. This stage has featured large US inflows in joint ventures with Mexican firms in the food and beverage industries, as well as large inflows into the auto industry. The latter include new investments from the three large American car producers, and from tire and engine manufacturers as well. Such investments by US investors have been accompanied at this stage by investments from Japan (Honda and Nissan) and Europe (BMW, Mercedes, VW).

Portfolio Investment Flows in Mexico

In 1996, the large inflows of portfolio foreign investment into Mexico were taken to indicate the great potential for industrial modernization. This is because, unlike Canada or the United States, Mexico has lacked a well-developed banking system, while it has suffered from very high interest rates. Historically, large Mexican firms have often financed their expansion plans with foreign bond or equity issues.

Thus, the trend of portfolio investment, especially into the equity market, and its destination provided additional information on the momentum for modernization in Mexican industry.

During the first NAFTA phase (1991–94), large outflows of these investments were observed, but with the advent of the peso crisis, a contraction took place in 1995. This included negative flows of portfolio investment in securities (bonds, commercial paper and government securities in pesos) and a weak inflow to equities.

The latter inflow tended to recover between 1996 and 1997, but it again became negative in 1998, as foreign investors withdrew from emerging markets. Table A-10 shows that portfolio investment was very high in 1992–93.

Table A-10: Foreign direct and portfolio investment in Mexico from the world, 1989–98 (millions of US$)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1991–94	1995–98
Total	3,669	4,828	12,302	22,434	33,308	16,166	-188	22,604	17,867	11,530	84,210	51,813
Direct	3,176	2,633	4,762	4,393	4,389	7,980	9,526	9,186	12,830	10,238	21,524	41,780
Portfolio	493	1,995	7,940	18,041	28,919	8,185	-9,715	13,418	5,037	1,293	63,085	10,033
Stock market	493	1,995	6,332	4,783	10,717	4,088	519	2,801	3,215	-666	25,920	5,869
Peso securities			1,606	8,147	7,406	-2,225	-13,860	908	585	214	14,934	-12,153
Public sector				8,147	7,013	-1,942	-13,791	948	490	290	13,218	-12,063
Private sector				0	393	-283	-69	-41	95	-76	110	-92
Dollar securities*				5,111	10,797	6,324	3,625	9,700	1,237	1,744	22,232	16,306
Public sector				1,552	4,872	3,980	2,994	8,909	-1,659	198	10,404	10,442
Private sector				3,559	5,925	2,344	632	801	2,896	1,546	11,828	5,875

* Includes securities denominated in other international currencies
Source: Bank of Mexico, *Indicadores Económicos*, February 1995, January 1996 and January 1999

Investments in equities through the stock market were motivated by the prospects of NAFTA improving the outlook for large, listed Mexican firms. The investments in peso securities were motivated by the high interest rates that Mexico paid to portfolio investors, combined with their perception of a strong peso.

The table shows that portfolio investment had started to weaken before the peso collapse, even in early 1994, although this was in contrast with the continued increase in direct investment. While the latter reached the record figure of $7.98 billion in 1994 (up from $4.389 billion in the preceding year), portfolio foreign investment was down to $8.185 billion (from $28.919 billion in the preceding year). Moreover, this amount included an outflow in peso securities and was only offset by a large increase in dollar securities issued by public and private sectors in the international capital market (although in both cases, the amount issued was also smaller relative to that of 1993).

In other words, in 1994, even before the economic crisis materialized, the trend in portfolio investment had started to diverge from that evident in direct investment. The reason is that foreign direct investment is made with a long-run horizon and usually the investor has control over the management of the firm. By contrast, portfolio investment reflects decisions to buy and sell positions of portfolio managers in firms regarded as opportunities or as risks.

In 1995, foreign direct investment continued to rise and actually accelerated. The peso devaluation did not deter FDI—if anything it actually contributed to its increase. For one thing,

Mexican assets bore more attractive prices. For another, the peso devaluation restored competitiveness to Mexican exports and automatically made FDI in manufacturing more attractive, especially if this was focused on foreign markets. NAFTA was a catalyst for this investment.

By contrast, portfolio foreign investment was negative, as Mexico had to redeem government securities sold by the foreign investors. In the equity market, which could have represented an opportunity to investors, the flows were very small, owing to the deep recession that Mexico was suffering and the high interest rates.

As Mexico was forced to rely much more on manufacturing, for exports became the only engine of growth during 1995 and most of 1996, domestic consumption, reduced wages and high unemployment discouraged investment in the equity market. This was because most of the companies listed on the Mexican Stock Exchange were closely related to sectors that had been the engine of growth prior to 1995. These included domestic consumption, financial services, real estate, banking, and production of other nontradable goods and services. By contrast, the largest exporters, being subsidiaries of multinational firms, are not listed on the Mexican Stock Exchange.

Being a sector of high growth, exports of manufactured goods during 1995–97 attracted increased FDI. The growth in manufactured exports paralleled FDI increases in the manufacturing industry and were related to the increasing economic integration of Mexico with the United States. NAFTA played a pivotal role in reaffirming the trends of this integration. Canadian FDI was also significant in some sectors, such as telecommunications equipment and auto parts, but to a much smaller degree than US FDI.

As FDI in manufacturing increased and Mexico cemented its position in manufacturing linked to US industry, FDI expanded to other areas. Some of these are directly related to manufacturing and exports, but others are only indirectly so—finance, infrastructure, electricity generation, and gas distribution.

Thus, during the period in which FDI has been consolidating, portfolio FDI has performed weakly, as indicated in Table A-10. The annual average of portfolio investment of $15.8 billion during 1991–94 fell to only $5.9 billion in 1995–98, or $6.6 billion excluding 1995, when the flows were negative. Even this smaller figure contains inflows relating to securities issued by the Government in the international bond market in 1995–96. The proceeds of these issues were largely used to repay international loans obtained in 1995 during the peso crisis (mainly from the US Treasury and the Canadian Central Bank), most of which were repaid in 1997. The repayment explains the negative flow that year.

Thus, amounts of portfolio investment in the stock market have been small even after the 1995 recession, despite the fact that the Mexican recovery was one of the most solid recoveries of emerging markets. During the period from 1995 to 1998, foreign equity in the stock market represented average annual flows of only $1.5 billion, compared to the flows of $6.5 billion between 1991 and 1994.

The peso devaluation and adjustment of the economy post-1995 hurt activities focused on the domestic market, especially consumption, while it favored manufacturing firms, in particular those who export. As few of the latter firms are listed, trends in the stock market mainly reflected the negative side of the adjustment.

One reason that large exporters are not listed in the Mexican stock market is that they consist of subsidiaries of multinational firms. These firms, however, have continued to expand in Mexico, increasing efficiency and profitability, and deepening their penetration into global markets. Such firms are key to growth in the NAFTA region through their increasing specialization, trade and foreign investment.

Table A-11 shows the composition of foreign investment in the Mexican stock market according to the sector of the issuing company. It can be seen that the value of such holdings has not recovered to the level of $54.5 billion recorded at the end of 1993. Although in 1997 the market had a large increase, this was followed by a fall in 1998. The fall was a general response of international investors in emerging markets to the debt default by the Russian Government and pressures on Brazilian markets.

Table A-11: Holdings of foreign investors of Mexican equities by sector, 1991–98* (millions of US$)

Sector	Dec. 1991	Dec. 1992	Dec. 1993	Dec. 1994	Dec. 1995	Dec. 1996	Dec. 1997	Dec. 1998
Mining	29.4	40.1	110.1	228.4	401.8	433.5	658.0	646.2
Industrials	1,620.4	1,807.8	5,506.2	3,921.7	3,525.7	6,820.7	9,738.0	6,869.9
Construction	1,730.3	2,241.2	7,320.8	4,788.0	2,690.7	3,909.0	5,291.5	2,695.2
Retail	1,096.6	2,509.2	5,253.7	3,368.3	1,844.2	2,509.7	5,674.8	3,551.7
Communications & transportation	12,854.8	18,133.6	25,929.8	16,063.7	12,027.9	11,834.2	19,073.3	15,841.1
Services	429.2	2,252.6	6,061.1	3,087.4	1,418.2	2,589.5	4,168.9	1,843.9
Holding companies	749.4	1,084.2	3,638.0	3,199.4	2,112.1	2,731.1	3,994.8	2,172.3
Others	19.3	599.2	684.6	-369.9	457.7	151.0	358.4	1,041.7
Total	18,531.5	28,668.0	54,484.3	34,287.1	24,478.3	30,978.7	48,967.7	32,578.6
Memorandum stock market index	1,431	1,759	2,609	2,376	2,778	3,361	5,229	3,960

*Capitalization values

Source: Bolsa Mexicana de Valores, *Indicadores Bursátiles.* Various issues.

By far the largest concentration of foreign investment is in the communications sector, especially Telmex, the largest issuer in Mexico. In 1999, we observe a recovery in both equity prices and flows to the stock market. This will eventually be reflected in a large increase in the balance from the value it reached at the end of 1998 ($32.6 billion). Although much of the foreign investment in portfolios is of a short-term nature (i.e., investors can flee by selling their positions at any moment), they have nevertheless helped Mexican issuers to finance many of their expansion projects. This was clearly the case in construction, retailing, communications (mainly telephones), and services during the first phase of NAFTA.

Mexican firms that have financed investment through the stock market have become much more transparent in their operations—not only to investors, but also to single-issue groups. These include unions, environmental groups, human rights and other groups promoting corporate governance and political rights. In other words, even portfolio investment that appears not to be closely related to the management of firms has in Mexico resulted in more information on what producers do. It has also led corporations to greater awareness of their responsibilities to local communities and the environment.

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