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EMERGING ISSUES IN AGRICULTURAL TRADE AND THE ENVIRONMENT

by

C. Ford Runge

Center for International Food and Agricultural Policy

University of Minnesota
332 ClaOff Building
1994 Buford Avenue
St. Paul, Minnesota 55108-6040 U.S.A.

Phone: (612) 625-8713
FAX: (612) 625-6245

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C. Ford Runge

Distinguished McKnight University Professor

of Applied Economics and Law

University of Minnesota

U.S.A.

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Emerging Issues in

Agricultural Trade and the Environment

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Introduction and Overview

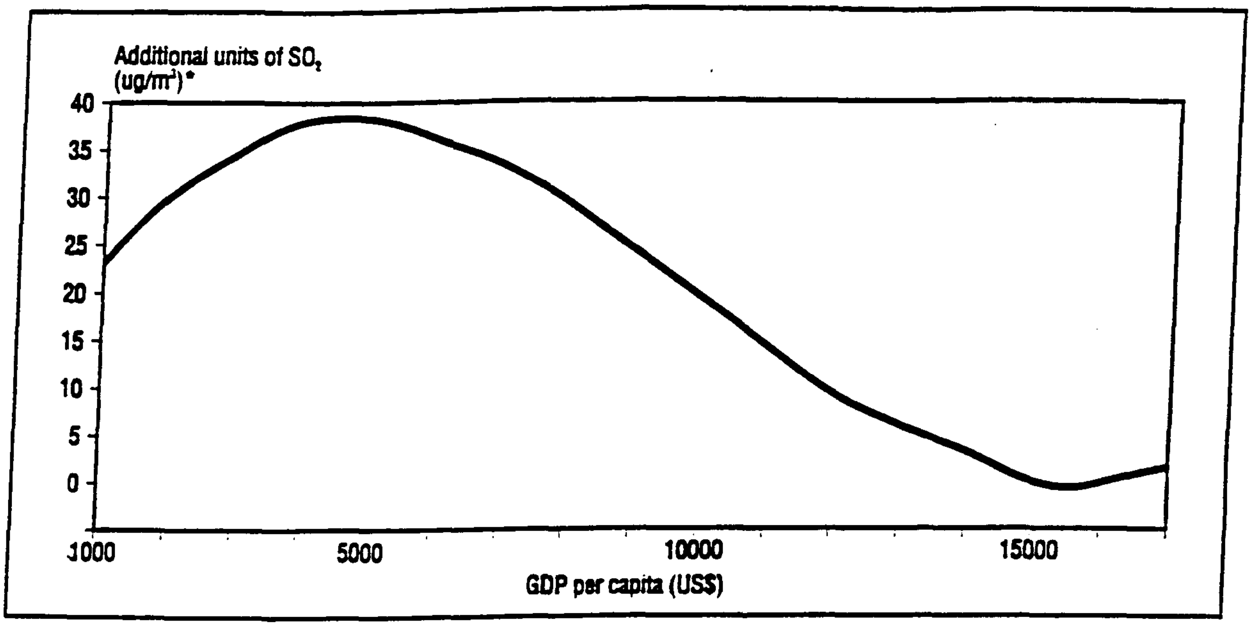
This paper outlines emerging issues in agricultural trade and the environment. Its intent is to provoke discussion, rather than to capture all of the issues and details that merit analysis. It focuses primarily on "micro" issues rather than global issues such as green house gas emissions or biodiversity, although these are in many respects simply the aggregation of questions that must be resolved by changes in practices and incentives at the farm level. It begins with a description of the stylized facts of trade-environment interactions, arguing that the widely cited "Kuznets function" underscores our ignorance concerning the mechanisms linking growth, trade, and pollution. Especially in agriculture, there is evidence that market and government failures have not yet led to substantial interventions to reduce environmental externalities. The second part of the paper discusses these mechanisms, and raises a set of research questions designed to guide OECD and other investigators toward a more detailed understanding of the linkages from trade to environment in agriculture. The third part of the paper explores the challenges posed for trade policy-making, touching on two of the most important future areas in agriculture: sanitary and phytosanitary (SPS) measures, and genetically modified organisms (GMOs), and offers some policy principles to advance agricultural sustainability. The final part of the paper raises some of the challenges likely to face the WTO as it grapples with these and other trade-environment issues in the next century.

Stylized Facts and the Kuznets Function

In the absence of a substantial body of empirical research, the short experience with trade and environmental policy interactions in agriculture has left us with a few stylized facts. These stylized facts have some rudimentary empirical support, but are far from well-understood. Perhaps the most important (although not specific to agriculture), is the Kuznets or inverted-U function that has been calculated for a variety of environmental pollutants, showing that as income (GDP/capita) grows, some pollutants rise, but then fall at a threshold level of income (see Figure 1). Appendix 1 summarizes most of the available evidence on this relationship. Appendix Table 1 provides a summary of a number of studies examining the data sources, pollution measures, media and results, as well as the level of GDP per capita at which various pollution levels peak. It is noteworthy that despite broad support for the Kuznets function, the thresholds at which pollutants turn downward are often very high, and some do not turn downward at the limits of the data. Sanguine interpretations of these findings, suggesting an automatic pollution-reducing response to income growth, are not supported.

Lucas (Appendix Table 2), in a separate analysis, has looked not only at the relation of environmental indicators to GDP/capita, but specifically at the relation between various environmental indicators and trade-openness measured by exports/GDP, finding that many pollutants are unassociated with export openness, and some indicators, such as wilderness area, are positively associated with openness, while deforestation is negatively associated with it. Naturally, his findings require replication and further analysis. In a recent report for the World Resource Institute (Appendix Table 3), I and others examined the relation between changes in export shares in Latin America and the Caribbean for numerous ISIC

Figure 1. Income and Pollution



Source: GATT (1992), p. 30, based on Grossman and Krueger (1991).

Figure 2. Conceptual Impacts of Trade Liberalization and Economic Growth on the Environment.

Trade Liberalization

⇓

Improved Resource Allocative Efficiency (+)

⇓

Growth in Income/GDP per capita (+)

⇓

Scale (Pollution) Effects (–)

⇓

Demand for Environmental Quality (+)

⇓

Change in Environmental Policy (+)

⇓

Change in Product Composition and Change in Production Technology

(less polluting or more amenities) (less polluting or more amenities)

Source: Ervin, 1997b, p. 27, adapted from Runge, 1995, p. 366.

sectors, and found that the highest polluting sectors were basic metals, industrial chemicals and non-metal products, whilst the lowest were textiles and apparel, metal products and food products. When export growth in these sectors was examined, it was by no means clear that export share was growing more rapidly in the highly polluting sectors; if anything, the opposite trend seemed better supported (Runge, et. al., 1997). While Mexico was the only OECD country considered, the methodology employed is easily generalizable to other OECD countries. We also examined trends in the agricultural sector, to which I shall return.

The most important consequence of these studies is to draw attention to what we do *not* know, both across sectors, and particularly within sectors such as agriculture, about trade-environment interactions, inside and outside the OECD. In this paper, I will focus on some of the reasons for our lack of understanding, and propose the elements of a research and policy agenda for OECD member governments and the WTO as they prepare for the next round of multilateral trade negotiations. The discussion begins with consideration of the *mechanisms* which link trade to changes in environmental quality in agriculture. It then moves to the most important policy challenge: how to establish this linkage in ways that promote reinforcing increases in market access and environmental quality. I will call this the *virtuous path*: increased market access leading to trade and income growth, out of which resources can and are devoted to environmental improvements. In contrast, but no less possible, are policies leading to a *vicious path*: denial of market access (justified in part or in whole on environmental grounds) leading to reduced trade and income, further reducing the resources that can be devoted to environmental initiatives. The paper concludes with a set of questions relevant to the WTO and its future program.

<u>Mechanisms of Linkage</u>

The *mechanisms* by which trade affects environment are not revealed by inverted U-shaped functions, which hide the technological and political choices leading nations and individuals to respond to pollution as a "public bad." These market failures demand attention to the incentives of individuals and nations to engage in collective actions to reduce these negative agricultural externalities over time (see Sandler, 1997). This leads to a decomposition of the impacts of trade on the environment which can allow us to discern if, how and why certain trends in the data occur. Let me sketch five such impacts of trade on the physical environment with special attention (although without loss of generality) to agriculture (see Runge, 1995).

The first and most celebrated (since Adam Smith) is *allocative efficiency*, the persuasive argument that specialization and comparative advantage more efficiently utilize natural resources than policies of national or local self-sufficiency, a view in direct contrast to extreme advocates of local self-reliance or food security. In agriculture, natural resources are likely to be more efficiently utilized if those countries with comparative advantages (say in grains or tropical products) produce them and trade for others. It is unlikely to be an efficient use of natural capital to produce and consume everything locally. The second effect of trade is on the *scale* of economic activity, involving the question of whether large scale economic activity creates more ecological "wear and tear." In agriculture, there are some strong arguments that excessive scale, brought on in part by trade, may lead to substantial environmental stresses, especially in the livestock sector (see Runge, 1998). The third effect is on the *sectoral composition* of output: are more or less

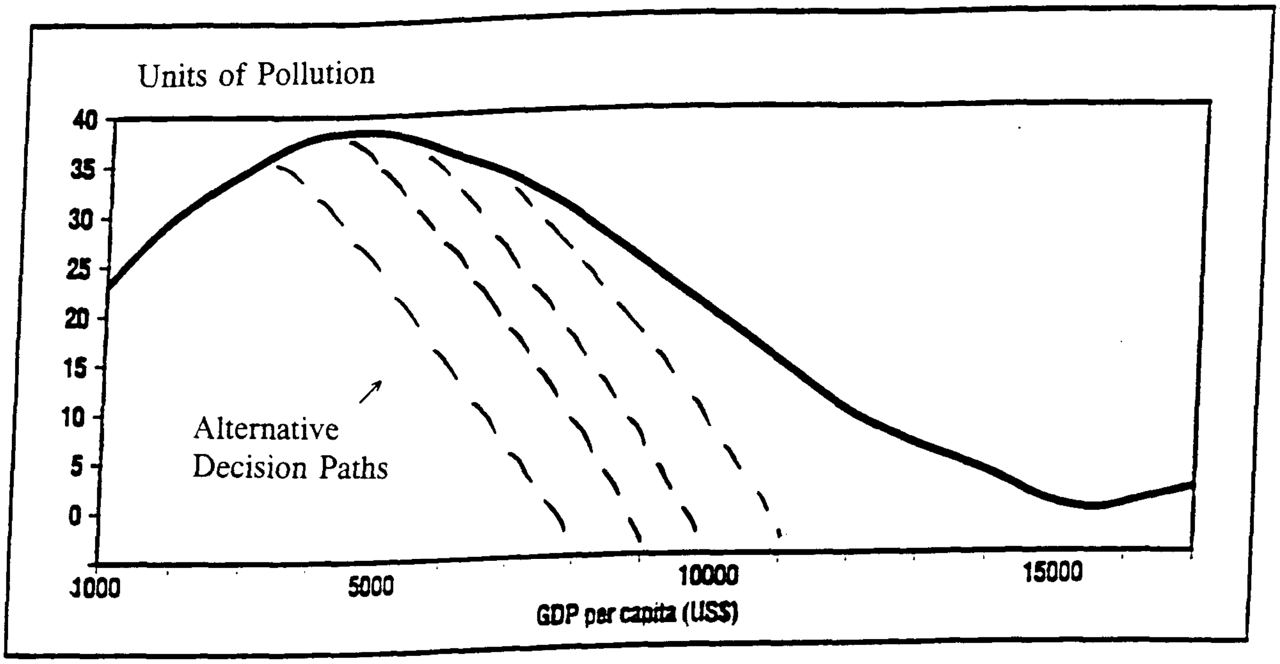
ecologically threatening sectors favored by trade? In the case of a specific sector such as agriculture, a deeper question concerns *intrasectoral composition,* For example, does trade encourage excessive production of more highly polluting crops such as cotton at the expense of small grains? A fourth way in which trade may affect the environment is by inducing *technological innovation* and transfer -- of both goods and bads. In the case of agriculture international diffusion of agricultural technology has been blamed for some of the excessive use of inputs such as fertilizers and agrichemicals, but has also allowed technologies used in soil conserving reduced tillage to be practiced more and more widely on crops such as corn and soybeans (Conservation Tillage Technology Center, 1997). A final, and perhaps the critical impact is on policy -- and politics. Whilst rising incomes may make environmental protection more affordable, the ultimate question is not only whether nations are *able* to pay for such protection, but whether they are *willing to pay and can reveal this preference through the political process*. Market failure is thus joined by the possibility of government failure in causing negative environment impacts to which societies fail to respond. In agriculture, this is a particularly vexing question. Despite a growing body of evidence demonstrating the broad environmental impacts of agriculture (only some of which are trade-related), the agricultural sector has continued to avoid the degree of environmental regulatory oversight common in many other sectors (Kalt, 1985). This is true not only in low- but also in high-income countries, clearly implying that income growth is a necessary but not a sufficient condition for environmental improvements in agriculture (Runge, et. al., 1994; Ervin, 1997a).

Schematically (Figure 2), we can think of trade liberalization in agriculture as inducing some allocative efficiencies, leading to increased income growth and GDP per capita, with some negative scale effects. *If* these effects lead to increases in demand for environmental protection, revealed in a political process, then changes in environmental policy, and induced technical changes and shifts in composition are more likely. But the critical possibility for disconnection, assuming at least some negative scale effects are not overcome by allocative efficiencies and market-based technologies, is whether the political process responds to the need to reduce environmental externalities in agriculture over time.

We can think of this problem in terms of an "endogenous" Kuznets function, in which social choices are made to foreshorten the path by which pollutants are reduced over time (see Figure 3). The question is whether the social resources necessary to effect this reduction are available, and, furthermore, whether collective decisions are made to reduce pollution at a more rapid rate.

This question lies at the heart of the debate over trade and environment. Obviously, the political process at both the national and the international level is only beginning to respond -- and grudgingly, to the negative environmental impacts of agriculture, in part because of the centrality of food security in national policies. Moreover, the data suggests that such responses are much less likely at lower levels of income, even in well-functioning democracies. In the United States and Western Europe, environmental responsibility and even corporate environmental activism are very much in favor with the public and a large part of the private sector. Even so, agriculture has largely escaped much of this oversight (Ervin, et. al., 1998). But in most developing countries, environmental regulation is

Figure 3. Income and Pollution



"Endogenous" Kuznets Functions

regarded as at best an affectation of the rich, and at worst an excuse to deny market access to Third World exporters as a form of "green protection." The central conundrum facing global environmental policy in agriculture is how to connect incentives for upward harmonization of environmental standards to the dynamic process of trade liberalization, while avoiding the use of "environmental conditionality" as an excuse for closing off market access (see Runge, et. al., 1997; Vogel, 1995). Before examining these issues from a policy perspective, let me summarize the implications of the discussion thusfar.

The impacts of trade on the environment illustrated in Figure 2 imply the need for OECD research organized around the following difficult questions:

(1) How much has trade liberalization driven changes in agricutural practices (with both positive and negative environmental effects) in various OECD countries to date, and how will it affect these practices in the future?

(2) Will increases in allocative efficiency reflecting comparative advantages in agriculture result in resource conservation, and if so, how can this "conservation via efficiency" be promoted (e.g., through adoption of conservation tillage)?

(3) As national income growth occurs, what share should be reserved to compensate for negative externalities in agriculture? How can intrasectoral environmental issues (e.g., cotton versus small grains) be given priority?

(4) Have trade-induced scale (pollution) effects in agriculture been adequately assessed, allowing estimates contributing to their remediation as in (3)?

(5) What is the structure of demand for (a) environmental quality as a public

good, and the (b) remediation of public bads and externalities from agriculture?

(6) What is the derived demand from (5) for changes in environmental policy, and how can such policies be successfully coordinated across OECD and developing countries?

(7) What technological processes and product characteristics can best promote environmental improvements in agriculture, without interfering with freer trade?

A more detailed set of research questions is developed in Appendix Table 4.

<u>Virtuous and Vicious Trade and Environment Linkages</u>

One of the conundrums of trade-environment interactions is that the constructive reinforcement of trade expansion and environmental improvement can so easily give way to a destructive spiral of protectionism and environmental damages. On the one hand, it is clear that poor countries do not protect their environment (except in the sense that they do not exploit their natural resources) because they cannot afford the technical choices and policies that would allow them to do so. Hence, economic growth, especially through the exploitation of comparative advantage via trade, appears a necessary condition for many environmental improvements. But while necessary, the available evidence (especially in agriculture) indicates that growth through trade is far from sufficient (Ervin, 1997a). In order to assure a virtuous path of trade-environment interactions, technical and policy decisions must be made that mitigate whatever damages increased trade may bring, and

promote principles such as that the polluter pays (see Figure 4). This is demonstrated as a matter of theory as well as practice (Anderson, 1992). Unfortunately, in much of the OECD, there is greater evidence of paying the polluter in agricultural policy than of the polluter pays principle (Runge, 1995).

On the other hand, it is equally possible that countries may be denied market access, in part or in whole on grounds of environmental protection, where the primary motive is not environment, but trade. This is a particular concern of developing countries, who see in many environmental standards nothing other than nontariff trade barriers and is an especially acute problem in agriculture. As market access to these countries is denied, it not only reduces their economic growth, and resulting capacity to mount environmental initiatives; it also reinforces a view of environmental standards and policies as affectations of the rich (see Figure 5).

Let me offer an example of each type of interaction, and suggest why the slope from a virtuous to a vicious linkage can be slippery. A first case is NAFTA, and its extension to a Free Trade Area of the Americas (FTAA) Agreement (see Tiefer, 1998). In the broadest sense, the linkage of environmental side agreements to the NAFTA text demonstrated a recognition that market access (especially to U.S. markets by Mexico) could be successfully traded for commitments to improve Mexico's environmental technology, infrastructure and policies. Despite difficulties in implementing this commitment, the establishment of the North American Commission for Environmental Cooperation (CEC) in Montreal is tangible evidence that new institutions dedicated to mitigating trade-related environmental damages can be created. Among the most prominent of the CEC's Nafta Effects Projects is a study of

Figure 4. Virtuous Trade-Environment Interactions

Trade Liberalization

⇓

Growth in GDP

⇓

Resources for Environmental Improvement

⇓

Environmental Policy and Technology Changes

⇓

Environmental Quality Improvements

Source: The Author.

Figure 5. Vicious Trade-Environment Interactions

Restricted Market Access

⇓

Decline in GDP

⇓

Fewer Resources for Environmental Improvement

⇓

Reduced Environmental Policy and Technology Changes

⇓

Environmental Quality Deteriorates

Source: The Author.

the agricultural sector, focusing on the beef cattle feeding industry in the U.S. and Canada and the white corn sector in Mexico (see Runge and Fox, 1998; Nadal, 1998). Yet in the further negotiations over an FTAA, many Latin American nations questioned whether such increased market access was worth the environmental conditionality it might imply (see Runge, et. al., 1997). There is analytical support for the proposition that while environmental interests are often served by such a linkage, it complicates and may reduce the probability of successful trade negotiations, a result confirmed in the stalled "fast track" authority necessary to move the FTAA forward (Hauer and Runge, forthcoming). In the context of the FTAA, and the parallel development of Mercosur, we specifically examined some trade-environment interactions in agriculture in Latin America and the Caribbean (Runge, et. al., 1997). In general, there is evidence that older, import substitution policies had distorted farmers' incentives, leading to the misuse of various inputs. However, in the face of liberalization, expanded scale effects may also threaten environmental quality.

Several examples of these impacts are noted in the case of Argentina by Cap (1996). A spectacular increase in the area subject to groundwater irrigation in the Pampean Region of Argentina is one such case. Although hard data on actually irrigated areas are not yet available, sales of irrigation equipment are booming and analysts estimate that one million hectares of corn and wheat may be irrigated by the turn of the century. The source of water used for this irrigation is the Puelches aquifer. Current information on the present and potential depletion rate as well as the recharging capacity of this aquifer is lacking. Partly as a consequence, no regulations exist specifying minimum distances

between wells or other practices affecting the property rights of those extracting water. The implications of the potential impact of this process on a critical component of the resource base of that region could be very serious. In the same region (the Pampas), other input use intensity has also skyrocketed. It has been estimated that for the planting season 1996, some 60 percent of the wheat was fertilized. In 1990, it was less than 10 percent. Resulting increases in concentrations of nitrates in groundwater will be the inevitable result. New conservation tillage techniques being adopted by farmers at a rate well above trend also implies the use of larger quantities of herbicides than before. While costs and soil erosion rates may decline, polluted water sources will rise.

The Latin American experience suggests that most governments, including Mexico, are only beginning to make political and technical choices which might reduce or remediate environmental damages from agriculture. While the first part of the virtuous path (trade expansion and income growth) has begun, it is far from clear whether resources can and will be set aside to internalize environmental externalities in agriculture.

Having acknowledged that even a virtuous path is difficult to follow, let us turn now to the less virtuous and more vicious possibilities. One is the continued attempt by U.S. congressional interests to restrict imports of fruits and vegetables from competitive producers in Mexico, Central and South America on the grounds that the pesticides used in these countries are not approved or are banned in the U.S. This "circle of poison" legislation, not surprisingly, has its origins with California fruit and vegetable interests.[1]

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[1]This response to differential pesticide uses is related to the larger claim that more open trade encourages the development of "pollution havens." For an empirical refutation of this claim, see Mani and Wheeler (1998).

Such import restrictions are justified largely on environmental and public health grounds, but call for import restrictions that raise many troubling issues for trade policy. The first and most obvious is the "extrajurisdictionality" of proposed U.S. actions against countries to which U.S. law does not extend; the second is the application of import restrictions not only to products, but to the process by which these products are grown and marketed. To the extent that such policies (including a wide range of sanitary and phytosanitary [SPS] measures) are pursued, trade policy may purport to protect the (U.S.) environment, but it will also close off market access, reducing incomes and the eventual capacity to mount "greener" production methods where these fruits and vegetables originate.

Such vicious interactions are especially likely to occur in two relatively new areas: SPS measures, and the rapidly emerging sphere of genetically modified organisms (GMOs). While these issues intersect with one another, it is useful to separate them out for analysis. The Uruguay Round Agreement on SPS represented recognition by the multilateral trading system that nontariff barriers are a major source of trade distortion, and are likely to grow over time. This is especially true where food and agriculture meet environmental and health concerns: the province of SPS. To date, however, implementing the SPS agreement has been difficult. Roberts (1998) notes in an evaluation of the Uruguay Round Sanitary and Phytosanitary Standards (SPS):

> **The challenge before the negotiators of the SPS Agreement was to create a set of rules which would strike the proper balance between allowing protection while disallowing regulatory protectionism. There are clearly public good arguments that make some SPS restrictions necessary to insure a safe food supply and protect the domestic environment from pests and diseases. In other cases, regulations rationalized on technical grounds seem to lack firm scientific foundations and, at least from the perspective of**

> **exporting countries, seem to be imposed primarily to thwart the commercial opportunities created by other trade liberalization policies...If the negotiators were successful, the SPS Agreement will be regarded as an important institutional innovation that counterbalances the influences of domestic interest groups that successfully lobby for SPS measures which lower net social welfare by restricting imports that pose negligible health or environmental risks (p. 2).**

However, as Josling (1994) noted

> **Although many view the new SPS Agreement as a significant advance, it is difficult to say how effective it will be in curbing trade disputes arising from health and safety standards. It could also lead to unwarranted changes in such standards. Many environmental and consumer groups fear that there will be an erosion of standards in the name of freer trade. The significance of these trade rules may soon be apparent. There are many important issues, such as inconsistent regulations on the use of Bovine Somatotropin in dairy production, different approaches to food irradiation, and disparate requirements for food labelling which threaten to burst on the trade scene and test these new SPS procedures (p. 17).**

The second area of emerging significance is agricultural biotechnology, or GMOs. These have been the subject of intense scientific interest and scrutiny for at least two decades. It is only in the last 3-5 years, however, that marketable products have emerged from this research that now promise to transform the agricultural landscape, affecting the environment, trade and food production in ways that are still largely unknown. The environmental, trade and food policy communities, in particular, have yet to formulate responses to the rapid emergence of biotechnologies in key commodities such as corn and soybeans. Beginning in crop year 1996, newly released varieties of genetically-engineered soybeans and corn (as well as cotton) were marketed in the U.S. for the first time. These

seeds, including Roundup-Ready® soybeans and Bt corn[2] are genetically engineered with traits that offer improved yield or other performance characteristics in the face of weeds or pests. Roundup Ready® soybeans, for example, are impervious to the effects of glyphosate (Round-up®), a widely-used herbicide, allowing reduced total herbicide applications and better targeting of weed control, as well as fewer passes through the field. Bt corn is genetically engineered to resist the European corn borer, a widely encountered corn pest, thus reducing the need for insecticide applications. Sales of both of these seeds have been brisk, growing from a few percentage points of total soybean and corn sales in 1996 to an estimated 10 percent for RR soybeans and perhaps 5 percent of total corn seed sales for Bt corn in 1997. In 1998, sales of modified soybean varieties will capture over 30 percent of the U.S. market. These seeds are only the first generation of what are expected to be a growing stream of genetically engineered seed varieties, known in trade circles as Genetically Modified Organisms (GMOs).

These dramatic developments have left a number of key issues unresolved. Each of these issues concerns a form of market failure. The first of these is the distribution of benefits and costs associated with the new "super seeds." As these technologies move through the product cycle from lead markets in developed countries such as the U.S., and into developing countries, will their benefits be proportional to the increased costs of utilizing them? How will they relate to questions of agricultural scale, and to small farmers in particular?

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[2]Bt stands for *Bacillus thuringiensis*, a bacterium present in soils that acts as a natural insecticide. This bacterium has been genetically engineered to be present in the corn plant itself, creating resistance to the European corn borer.

A second issue related to possible market failures concerns the concentration of industrial control over these technologies. As a result of breakneck merger and acquisition activity in the U.S. and Europe, a relatively small number of large agricultural input and pharmaceutical companies are coming to dominate research and technology in the field of crop biotechnology. On the one hand, this will allow huge expenditures on the technology and its dissemination. On the other hand, the control and concentration of the industry raises questions over access to the technology and the use of market power to extract monopoly rents.

A third area of market failure relates to a number of externality and public goods questions, involving biological and ecological risks. The two primary risks are that herbicide resistance may be transferred from genetically engineered plants to close plant relatives that are undesirable, including numerous weed pests.[3] The second is that plant resistance to insect pests will in turn cause insect mutations and counter-resistance, creating new and even more virulent insect pests. In order to prevent such mutations from taking hold, it is generally stipulated that farmers planting the insect resistent varieties continue to reserve a portion of their fields ("refugia") for traditional non-resistent crops, thus ensuring the survival of a pool of non-resistent insects.

Related to these market failures are several key features that make them emblematic of issues of sustainability in agriculture. The first feature is that the commercial and even the environmental benefits of crop biotechnology occur sooner in time than the risks. The

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[3]While this possibility is considered remote in the case of soybeans, other genetically engineered crops, such as genetically engineered canola, have closer relatives (e.g., wild mustard) in which the transfer of resistance is more possible.

avoidance of weed and insect pests occurs as soon as the crop is planted and harvested, together with the tillage and insecticide reductions noted above. The development of weeds and insects even more resistent to herbicides or insecticides, in contrast, will follow in future generations of plants and insects. No one knows how rapidly such resistance will occur (if it occurs at all), but it will certainly be further in the future than the current crop year. A fundamental principle of economics holds that insofar as individuals give greater weight to current as opposed to future consumption and production, they will discount future risks relative to current benefits, in effect downgrading the significance of costs to future generations.

The second feature is that the risks of plants and insect resistance, if they occur, will be spread over a landscape that includes many growers of crops, and are in no way likely to be borne solely by the adopter of the new varieties. The fact that these risks are not internalized makes them a form of spatial externality, in which the costs of resistance are spread widely, while the benefits, at least initially, are concentrated in the hands of early adopters. Hence, the spatial externalization of risks interacts with the temporal asymmetry noted above, as early adopters push risks both outward in space and forward in time.

A third feature of the benefits and risks associated with crop biotechnology involves the disincentives of farmers to reserve a portion of their fields as refugia to create a preserve for insects that lack resistance to the new varieties. These disincentives arise because the benefits of such refugia are not fully captured by the farmers. Indeed, the crops in refugia will be vulnerable to the very pests against which farmers seek to insure by adopting the new varieties. The benefits are thus partly public goods, insofar as they

return to all farmers seeking to maintain the efficacy of the new insect-resistant varieties. However, refugia are also designed to protect the investments of large seed and chemical companies by prolonging the efficacy of the new seed varieties. As in all cases of public goods, farmers have an incentive to free ride by shirking their responsibilities to maintain refugia, thus undercutting the long-term efficacy of the new varieties, and coincidentally reducing the long term payback to private investors. Finally, and ironically, insofar as private investors anticipate this behavior, they may seek to maximize short run sales of seed at the expense of maintaining refugia reserves.

These environmental issues are linked in turn to trade. The proliferation of GMOs has catalyzed international debate on world trade policy and standardization. The United States and the European Union (EU) have sparred over the validity of trade restrictions on these agricultural products. The United States, an exporter of GMOs to Europe, is advocating free trade in these materials. The current EU proposal is to mandate labeling of all agricultural products containing GMOs. This implies the need for standards for GMOs, such as those that would require all seed products containing greater than a specified amount of GMO product to be labeled as such. This type of standard would increase processing and transport costs and is interpreted by many in the industry as a form of nontariff trade barrier (NTB).

Europe has generally favored a higher standard of segregation of GMOs from non-GMOs, while the U.S. has argued for less or no segregation. Suppose a compromise is reached to harmonize, requiring that Europe drop its standards for segregating GMOs, but also requiring the U.S. to raise its labeling requirements. In Europe, producers surplus

would initially fall as competitive U.S. exports of GMO oilseeds and feedgrains enter the European market, less impeded by EU standards. However, European producers would gain access and the ability to produce GMOs themselves, quickly regaining a competitive edge. Consumers surplus would increase with less expensive foodstuffs, but could fall if consumers fear GMOs as a form of health risk. Hence the EU negotiating stance on the proposed harmonized standard will depend on the perceived competitiveness effects on producers and the perceived health risks to consumers. (A recent referendum in Switzerland suggest that opposition to GMOs may be less than thought, making a European compromise more probable.) In the U.S., raised labeling requirements may raise costs and reduce producers surplus, but these costs would be offset by expanded market access to the EU. Consumers would gain if the labeling requirements do not appreciably affect food costs and increase the perception of food safety.

How, then, can one advance virtuous while avoiding vicious paths of trade-environment interactions? Neither my virtuous nor my vicious paths suggest that liberalization automatically leads to environmental improvements. The virtuous path presents liberalization as necessary to such improvements, but not sufficient. The vicious path, which leads to restricted access and reduced growth, closes off even the necessary condition. The analysis and assessment above yields a number of organizing principles for the conduct of more sustainable trade policies. I appeal here to four principles for sustainable trade policy (Runge, et. al., 1997).

Principle 1: Whenever agricultural trade and environmental policy issues intersect, both sets of policies should be adjusted so as to maximize the complementarity of trade reform and environmental sustainability.

It is clear from the record of trade liberalization that environmental considerations have often been quite separate from strategies of liberalization and have been given much lower priority. If higher priority is now to be given to environmental issues, it will require a new set of instruments, primarily aimed at high pollution and extractive sectors, notably agriculture. Both the institutions and technologies required will not occur due to trade policy reforms alone. It is also unclear whether the nascent environmental authority granted to agencies such as NAFTA's Commission on Environmental Cooperation (CEC) are capable of dealing with the wide range of issues involved without substantial strengthening.

This first principle emphasizes the need for both trade and environmental policies to be rearranged when problems cut across the two spheres. Several examples emerge from the sections above. First consider upward harmonization of standards for GMOs. In order to achieve upward harmonization of such standards, not only must the U.S. and other OECD countries be prepared to reward such action through maintained market access, but certain industries must be prepared to face somewhat higher costs of doing business, notably bulk handlers of commodities. However, one cannot ask countries to adjust standards so rapidly that market access gains are wholly dissipated. The GMO debate seems more likely, at present, to proceed along a vicious than a virtuous path (see Gray, et. al., 1995).

Principle 2: Sustainable agricultural development will require environmental damages (externalities) to be explicitly recognized and, where possible, reduced or eliminated (internalized) through the application of the polluter-pays-principle or other environment policy reforms that emphasize pollution prevention.

The development and transfer of pollution-preventing technologies in agriculture will only occur at meaningful levels if governments begin seriously to enforce more stringent environmental standards, and require violators to pay the costs of environmental damages. In the agricultural sector, for example, excessive use of groundwater for irrigation can only be controlled if such use is carefully monitored and evaluated, and regulations are put in place that create incentives to establish a scarcity value for its use. There are enormous gaps in the regulatory and enforcement capacity of OECD countries confronting agricultural externalities.

An important issue here relates to claims that agricultural externalities are really an "implicit subsidy" to agriculture. Whether non-internalization of externalities is an implicit subsidy, and thus actionable under the subsidies code or in some other way, turns on property rights definitions. Do agriculturalists have the right to pollute? Thusfar, the evidence in the OECD is that they do, in which case there is no implicit subsidy from non-internalization. If, on the other hand, they are polluters who should pay, but do not, then they are receiving an implicit subsidy by not internalizing externalities. Hence, only if the polluter pays principle applies, but is not enforced, does an implicit subsidy exist from non-internalization.

Principle 3:** **The uncertainty surrounding both economic and environmental indicators in agriculture, and rapid technological changes exemplified by biotechnology, all imply that a proactive set of agricultural trade and environmental policies be one of "no regrets," in which reforms will prove beneficial no matter what.

The difficulty of establishing definitive linkages from trade to environmental impacts cannot become a basis for inaction. Instead, efforts must be undertaken to mitigate environmental damages. If it is later learned that trade aggravates these damages, then a safety net to protect the environment will already be in place. These issues arise with particular force in relation to the uncertainties related to crop biotechnologies, and SPS measures. Too stringent applications of "no regrets" policies can, unfortunately, degenerate into agricultural protectionism against any new technologies.

Principle 4:** **Implementing both agricultural trade and environmental policy reforms will require much clearer definitions of property rights, respecting not only goods and services, but "bads" and "disservices" including environmental pollution.

In many respects, the most important challenge facing the OECD will be to develop the political will and economic capacity to redefine rights and duties respecting environmental damages, acknowledging not only that these damages do real harm to individuals, but that firms and industries cannot escape responsibility for their impacts. Expanded trade will require clearer definitions of rights and duties for goods and services. A protected environment will require clearer definitions of right and responsibilities for "bads" and "disservices." These issues arise with force in the case of intellectual as well as

physical property, notably in the example of GMOs. Who will bear the costs of environmental damages from these innovations, if they occur? Conversely, who will reap the benefits that GMOs appear ready to provide? Will these groups be the same, or different?

The WTO and Its Program

Although this paper is directed to OECD research and policy, it is clear that the WTO program will be fundamental as we move toward a new round of multilateral negotiations in agriculture. Accordingly, the following comments are made, on the author's own responsibility, to the WTO and its secretariat.

The post-Uruguay Round experience of the WTO dealing with trade-environment interactions has been troubled. The Committee on Trade and Environment (CTE), formed in 1995 to confront at least some of the issues, found its report to the Singapore ministerial in December, 1996 widely criticized (Guruswamy, 1998). This author (Runge, et. al., 1994) and Esty (1994) have argued that the WTO cannot be expected to carry the main responsibility for trade-environment interactions, and it is fairly clear that it will not. Shaw (1997, p. 106), reporting on the post-Singapore agenda, recently noted: "There is no intention that the WTO should become an environmental agency, nor that it should get involved in reviewing national environmental priorities, setting environmental standards or developing global policies on the environment." Given this institutional gap some (e.g., Guruswamy, 1998) have called on existing international bodies, such as the United Nations

Convention on the Law of the Sea (UNCLOS) to fill the void.[4] Others (Runge, et. al., 1994; Esty, 1994) have called for a more inclusive authority under a World Environment Organization (WEO). Realistically, such an authority is unlikely to arise for some time, although the need for it, based on the same logic as the CEC in Montreal, will eventually become obvious.

In the interim, it is reasonable to ask how the WTO can structure its programs so as to deal with trade-environment issues, inside and outside of agriculture, in ways consistent with the relative lack of understanding of mechanisms, and the failure to integrate trade and environmental policies. Having already stated a set of research objectives for OECD, and a set of principles designed to facilitate sustainable trade expansion, I conclude with a set of questions (rather than recommendations) for the WTO Secretariat to ponder.

First, does the WTO have an environmental role and responsibility at all, or would it fare better to externalize all such issues? **Following Principle 1 above, it would seem the safest course for the WTO to take up issues of environment only where a straightforward trade rationale is present, and to seek to shift responsibility for environmental questions to a designated body of environmental experts. For example, various environmental groups**

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[4]According to Guruswamy (1998, p. 288): "Environmentalists have a number of reasons to fear this assertion of jurisdiction by GATT/WTO. First, the substantive law of GATT/WTO ignores international law dealing with environmental protection and treats any law or treaty not embodied in GATT or its `Covered Agreements' as irrelevant. Second, the track record of GATT litigation demonstrates the extent to which international environmental protection has been diminished. ...GATT panels view international environmental law trade restrictions as obstructions to the painfully engineered legal regime created by the GATT/WTO which is aimed at liberalizing trade by eliminating controls and restrictions. Third, the judges who interpret such substantive trade law are unfamiliar with, and possibly unfriendly toward, the laws and agreements directed at international environmental protection. Furthermore, these judges are prevented from engaging in the customary judicial role of interpreting and developing the law."

have recently sought to attack EU fisheries subsidies, and their environmental impacts, as trade distortions per se. In such a case, environmental issues really need not arise as a matter of consideration within the subsidies code at all. Such subsidies are unlikely to be defended under the Article XX exceptions! However, it would be useful for WTO, perhaps in collaboration with FAO, UNCLOS or other bodies, to have access to a body of environmental experts to whom environmental issues could be referred for an advisory opinion. The consequence of such an exclusionary approach, following the doctrine of *forum non conveniens*, would acknowledge the limits of WTO's expertise and authority (see Guruswamy, 1998).[5]

In many ways, the WTO has already signaled its strong aversion to engaging environmental issues. However, the lack of an alternative forum for referral underscores the need for one. The approach here would presumably resemble the deference paid in Sanitary and Phytosanitary issues to the Codex Alimentarius of the FAO. Indeed, it is not inconceivable that the Codex itself could be expanded to accommodate (at least in the agricultural sector) expertise on agroenvironmental issues and genetically modified organisms.

***A secondary question for the WTO is: what deference should be given to such alternative fora?* If such a group of environmental experts is purely advisory to the dispute settlement procedures of the WTO, then the implication is that its judgements have no**

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[5]The doctrine of *forum non conveniens* was described succinctly by Paxton Blair in his classic article as "the discretionary power of a court to decline to exercise a possessed jurisdiction whenever it appears that the cause before it may be more appropriately tried elsewhere" (Blair, 1929).

binding authority. Yet, the greater its capacity to exercise such authority, the more likely are environmental measures that impose on trade liberalization and market access. My own opinion, consistent with the principles adumbrated above, is that such an imposition is both necessary and proper, but must have the authority and integrity of expert opinion, expertly applied.

Third, if such a multilateral environmental authority is created, how should WTO seek to guide its development and evolution? **If the experience with the North American Commission for Environmental Cooperation (CEC) is any guide, trade ministries will remain jealous of ceding any authority to groups of environmental experts, and will seek to limit their role and function as much as possible. Since WTO is essentially an extension of the trade ministries of its contracting parties, it is therefore unlikely to support any more than minimal independence for such a group. Therefore, its political base of support will be likely to come from NGOs or environmental ministries. Unfortunately, these groups are those most suspect to trade ministries, implying a long and laborious process of institutional innovation before a multilateral environmental authority is created.**

Even so, it is this author's opinion that the need for such an institution will lead to its creation. Just as the logic of international economic interdependence (a "commercial commons") created an imperative for the GATT/WTO rules, so the logic of international ecological interdependence will one day require a separate code defining transnational rights and obligations to deal with transboundary environmental questions. In these matters, agriculture, notably in cases such as SPS and GMOs, may lead the process, in contrast to its laggard role in the process of commercial trade liberalization under GATT.

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Appendix Table 1. Summary of Empirical Results on the Relationship between GDP and Environmental Quality.

Authors	Source of Data	Pollution Measures	Pollutants	Medium	Results	Functional Form for GDP Variable	GDP per capita in $ at Peak Level of Pollution
Grossman and Krueger (1995)	GEMS[1]	Concentration (units of pollutant/volume of water or air)	SO_2	Air	Inverted U	cubic	4,053[5] (355)[6]
			Dark Matter or Smoke	Air	Inverted U	cubic	6,151 (539)
			Suspended Particles	Air	Downward	cubic	NA
			Lead	Water	Inverted U	cubic	1,887 (2,838)
			Cadmium	Water	Inverted U	cubic	11,632 (1,096)
			Arsenic	Water	Inverted U	cubic	4,900 (250)
			Mercury	Water	Inverted U	cubic	5,047 (1,315)
			Nickel	Water	Inverted U	cubic	4,113 (3,825) (1985
			Fecal Coliforms	Water	Inverted U	cubic	7,955 (1,296) US$[7])
			Total Coliforms	Water	Inverted U	cubic	3,043[8] (309)
			Nitrates	Water	Inverted U	cubic	10,524 (500)
			BOD[2]	Water	Inverted U	cubic	7,623 (3,307)
			COD[3]	Water	Inverted U	cubic	7,853 (2,235)
			Dissolved Oxygen	Water	U - Shape[4]	cubic	2,703 (5,328)
Lucas, Wheeler, and Hettige (1992)	World Bank PPS[9]	Emissions (Weight of releases/GDP)	Weight of 320 toxic releases	Air, Water and Land	Inverted U	quadratic	12,500 (1987 US$)

[1]Global Environmental Monitoring System

[2] Biochemical Oxygen Demand.

[3] Chemical Oxygen Demand

[4]Dissolved oxygen is a positive indicator of environmental quality, hence the relationship is the inverted with respect to the other indicators. The trough is reported under the pollution peak column.

[5] For cubic functional forms the peak level is a local maximum.

[6] Statistics in brackets are standard errors.

[7] Per capita income in purchasing power parity terms came from Summers and Heston (1991).

[8] The authors report a strange relationship with this pollutant. Total coliforms at first increase with income and then decrease. However, they then increase dramatically -- within the range of the data.

[9]World Bank Pollution Projection System

Appendix Table 1. Summary of Empirical Results on the Relationship between GDP and Environmental Quality, continued.

Authors	Source of Data	Pollution Measures	Pollutants	Medium	Results	Functional Form for GDP Variable	GDP per capita in $ at Peak Level of Pollution
Shafik and Bandyopadhyay (1992)	World Bank	%of population with access to safe drinking water or sanitation, concentration[10], change in forest area, concentrations[11], kilograms per capita[12], metric tons per capita[13]	Lack of safe drinking water Lack of urban sanitation Dissolved oxygen Fecal coliform Annual deforestation Total deforestation[14] Suspended Particles SO_2 Municipal solid waste Carbon	Water Water Water Air Air Land Air	Downward trend Downward trend Downward trend Inverted U then Upward trend Inverted U Inverted U Inverted U Inverted U Upward trend Upward trend	linear, quadratic and cubic[15]	NA NA NA 1375 (PPP$) Not reported Not reported 3280 3670 NA NA
Holtz-Eakin and Selden (1992)	Oak Ridge Nat. Lab.	Emissions	CO_2	Air	Inverted U	quadratic	35428 (1986 US$)
Selden and Song (1994)	World Resource Institute	Emissions	SO_2 NO_x Suspended Particles CO	Air Air Air Air	Inverted U Inverted U Inverted U Inverted U	quadratic quadratic quadratic quadratic	8916-10682[16] 12041-21773 (1985 US$) 9811-9617 6241-19092

[10]Concentration measures were used for dissolved oxygen and fecal coliform bacteria in rivers.
[11]Concentrations in micrograms per cubic meter for suspended particles and SO_2.
[12]This measure is for municipal solid waste.
[13]This measure is for CO_2 emissions.
[14]Total deforestation in hectares since 1961.
[15]All variables were log transformed.
[16]Selden and Song estimated a fixed effects and random effects model for each pollutant. The first number is for the fixed effects model and the second for the random effects model.

Appendix Table 1. Summary of Empirical Results on the Relationship between GDP and Environmental Quality, concluded.

Authors	Source of Data	Pollution Measures	Pollutants	Medium	Results	Functional Form for GDP Variable	GDP per capita in $ at Peak Level of Pollution
Lucas (1996)	Oak Ridge National Laboratory, World Bank PPS, World Resources Institute	Emissions 1000 tons, lbs/year/million US$ of manufacturing output (toxic release and water), lbs/yr/thousand US$ of manufacturing output (air), Area in km^2, Area in 1000 ha, Volume km^3 (Water), tonnes (pesticides)	CO_2	Air	Increasing Trend	quadratic	24,568[23]
			Total Toxic Release[17]	All	Inverted U	quadratic	10,500
			Bioaccumulative Metals	All	Inverted U	quadratic	5,250[24]
			BOD	Water	Inverted U	quadratic	17,750[24]
			Suspended Solids Suspended	Water	Inverted U	quadratic	6,300
			Particles	Air	Downward Trend	quadratic	NA
			SO_2	Air	Downward Trend	quadratic	NA
			NO_2	Air	Downward Trend	quadratic	NA
			Fine Particles (PM10)	Air	Downward Trend	quadratic	NA
			Lead	Air	Downward Trend	quadratic	NA (1987 US$)
			VOC[18]	Air	Inverted U	quadratic	20,000
			Wilderness	Land	Inverted U	quadratic	1,715-11,740
			Deforestation	Land	Inverted U	quadratic	1,960
			Fresh Water Withdrawals	Water	Increasing Trend	quadratic	NA
			Pesticide Use	Land, Water	Inverted U	quadratic	1,715-13,750
			Threatened Species: Fish		Inverted U[19]	quadratic	Not Reported
			Amphibians		Increasing Trend[20]	quadratic	NA
			Reptiles		Not Related[21]	quadratic	NA
			Birds, Mammals		Inverted U	quadratic	9,000
			CFCs	Air	Increasing Trend[22]	quadratic	NA
			Solid Waste	Land	Inverted U	quadratic	13,000

17 Weighted average of 320 toxic releases.
18 Volatile Organic Compounds.
19 This result was sensitive to inclusion of variables other than income per capita and population.
20 This result was derived by the author from statistical results in Lucas (1990).
21 Does not appear to rise or fall with income per capita.
22 Lucas (1990) reports this as a weak inverted U-shape, but the peak level of income was beyond the range of the data.
23 This income is outside the range of data.
24 This estimate was calculated by the author from results provided in Lucas (1996).

Source: Hauer, 1997.

Appendix Table 2. Estimated Relationship between Environmental Indicators, Growth, and Trade

Environmental Indicator[1]	Follows GDP/capita	Follows Growth in Income	Follows "Openness Index" (Exports/GDP)	Follows Time Trend	Population
(1) Annual CO_2 Emissions[2]					
(a) Total	+	0	0	0	NR[8]
(b) Solid Fuels	+	0	–	0	
(c) Liquid Fuels	–	0	0	0	
(d) Gas Fuels	+	0	0	+	
(e) Gas Flaring	+	0	+	–	
(f) Cement Manufacture	+	0	0	+	
(2) Pollution Intensity[2]					
(a) All media: total toxins	+	0	+	+	NR
(b) Water Polluting: BOD	0	0	–	0	
(c) Air Pollution					
i. Suspended Particles	0	0	–	+	
ii. SO_2	0	0	0	0	
(3) Wilderness Area[3]					
(a) Adjusted for Total Area	+	NR	+	NR	0
(b) Adjusted for Agricultural Land Use	+	NR	+	NR	0
(c) Adjusted for Forestry Practices	+	NR	+	NR	–
(4) Deforestation[4]					
(a) Adjusted for Total Area	+	NR	–	NR	–
(b) Adjusted for Agricultural Land Use	+	NR	–	NR	–
(c) Adjusted for Forestry Practices	+	NR	–	NR	–
(5) Freshwater Withdrawals[5]					
(a) All countries	+	NR	0	NR	+
(b) Adjustment for Total Water Available	+	NR	0	NR	+
(c) Adjusted for Agricultural Land Use	–	NR	0	NR	+

Table 2 (concluded)

Environmental Indicator[1]	Follows GDP/capita	Follows Growth in Income	Follows "Openness Index" (Exports/GDP)	Follows Time Trend	Population
(6) Marine Catch[6]					
(a) Adjusted for Exclusive Economic Zone	–	NR	0	NR	0
(b) Adjusted for Meat Output	–	NR	0	NR	0
(c) Adjusted for Freshwater Catch and Aquaculture	–	NR	0	NR	0
(7) Pesticide Use-Active Ingredients Used[7]					
(a) All countries	+	NR	–	NR	0
(b) Adjusted for Climatic Zone	+	NR	–	NR	0

Notes to Table:

[1]Entries of +, 0 and – indicate a significantly positive, insignificant and significantly negative statistical association at the one-tailed 95th percentile of confidence, respectively. These correspond to "positive," "none" and negative in the charts in Appendix I.

[2]Fixed Effects Time Series Models. Annual CO_2 emissions in 1,000 tons for 113 countries. All media, water pollutants and air pollutants measured as emissions flows in lbs. per year per U.S. million dollars of manufactured output for 96 countries.

[3]"Wilderness" defined as a minimum of 4,000 km^2 showing no evidence of human development. Data from World Resources Institute analysis of aerial photographs.

[4]"Deforestation" in units of 1,000 hectares.

[5]"Freshwater withdrawals" in km^3.

[6]"Marine Catch" in 1,000 tons.

[7]"Pesticides" in tons of active ingredient.

[8]NR indicates not reported.

Source: Adapted from R.E.B. Lucas. "International Environmental Indicators: Trade, Income and Endowments." Chapter 16 in M.E. Bredahl, et. al. (eds.) *Agriculture, Trade and the Environment: Discovering and Measuring the Critical Linkages*. Boulder, CO: Westview Press, 1996.

Appendix Table 3. Changes in Export Shares of Production for Low and High Pollution Intensive Sectors in Latin America

		Change in Export Shares of Production Low-Intensity Polluters		
Country	*Time Period*	*Textiles, Apparel*	*Metal Products*	*Food Products*
Argentina	1993	13%	8%	14%
Belize	90 and 92	-	Rising (54-58%)	Falling (62-53%)
Bolivia	88-91	Rise then fall (19-32%)	Rising (2-3%)	Rising (9-21%)
Chile	86-91	Rising (2-9%)	Falling (45-9%)	Steady (18%)
Colombia	86-91	Rising (13-36%)	Fall and Rise (5-11%)	Rising (3-5%)
Costa Rica	86-91	Rising (27-43%)	Fluctuating (24-27%)	Rising (7-11%)
Ecuador	86-90	Rising (1-5%)	Rising (2-4%)	Fall then steady (56-10%)
El Salvador	92	43%	24%	7%
Guatemala	85-88	Rise then fall (19-9%)	Rise then Fall (14-6%)	Rise then fall (9%)
Honduras	85-88	Steady 5%	Fall (6-5%)	Falling (9-6%)
Mexico	86-92	Fall then rise (41-51%)	Rising (23-61%)	Falling (8-4%)
Panama	85-89	Rising (20-43%)	Rising (2-8%)	Falling (9-5%)
Paraguay	1991	33%	19%	56%
Peru	86-88	Falling (15-8%)	Falling (38-32%)	Rising (8-22%)
Uruguay	86-90	Falling (57-51%)	Falling (9-6%)	Fall then Rise (26%)
Venzuala	85-92	Rising (1-4%)	Fluctuating (4-7%)	Rising (1-3%)

		Change in Export Shares of Production High-Intensity Polluters		
Country	*Time Period*	*Basic Metals*	*Industrial Chemicals*	*Non-Metal Products*
Argentina	1993	14%	8%	3%
Belize	90 and 92	-	-	-
Bolivia	88-91	-	-	-
Chile	86-91	Rising (48-62%)	Rising (7-10%)	Rise then Fall (1-3%)
Colombia	86-91	Rising (11-24%)	Rising (11-14%)	Fall and Rise (8-12%)
Costa Rica	86-91	-	Rising (16-21%)	Steady (16-15%)
Ecuador	86-90	Rising (0-2%)	Fluctuating (1-16%)	Rising (0-3%)
El Salvador	92	61%	15%	8%
Guatemala	85-88	Rise then fall (11-2%)	Rise then fall (15-8%)	Rise then Fall (11-5%)
Honduras	85-88	-	Falling (4-3%)	Rising (0-6%)
Mexico	86-92	Falling (22-13%)	Falling (21-16%)	Rise then Fall (14-10%)
Panama	85-89	Rising (11-22%)	-	Rising (1-6%)
Paraguay	1991	-	47%	0%
Peru	86-88	Rising (3-6%)	Steady (10%)	Steady (2%)
Uruguay	86-90	Falling (17-13%)	Rising (8-13%)	Rising (7-13%)
Venzuala	85-92	Falling (61-38%)	Falling (60-50%)	Falling (19-11%)

Source: P. McGinnis and P. Faeth, WRI, 1997, in Runge, et. al., 1997.

Appendix Table 4. Detailed Research Issues*

(1) **How much has trade liberalization driven changes in agricutural practices (with both positive and negative environmental effects) in various OECD countries to date, and how will it affect these practices in the future?**

Specifically:

- **What are the causal links from more open trade to farming practices, and then to environmental impacts?**
- **Can these causal links be empirically documented?**
- **Is it necessary to lay the burden of these impacts on trade changes, or should trade be recognized as simply one factor among many?**
- **How are environmental benefits from agriculture, such as countryside maintenance, to be figured in relation to damages and costs?**

(2) **Will increases in allocative efficiency reflecting comparative advantages in agriculture result in resource conservation, and if so, how can this "conservation via efficiency" be promoted (e.g., through adoption of conservation tillage)?**

Specifically:

- **What case studies can be developed showing the allocative efficiencies and environment impacts of modern agricultural technologies?**
- **How has trade expansion increased the rate at which these technologies are disseminated?**
- **Can the "product cycle" describing this dissemination be speeded up through research, policy choices, or coordinated national decision making?**

***These are intended to amplify points (1)-(7) on pp. 10-11 of the text.**

Appendix Table 4. Detailed Research Issues, continued.

(3) As national income growth occurs, what share should be reserved to compensate for negative externalities in agriculture? How can intrasectoral environmental issues (e.g., cotton versus small grains) be given priority?

Specifically:

- **Can a relatively simple "damage function" for agricultural externalities be developed?**
- **Can this damage function be employed to estimate and compare "producer damage equivalents" (PDEs) both across countries and intrasectorally, á la PSEs?**
- **Once such damages are known, can tax/subsidy schemes be targeted to them so that polluters pay and those who reduce damages are subsidized?**

(4) Have trade-induced scale (pollution) effects in agriculture been adequately assessed, allowing estimates contributing to their remediation as in (3)?

Specifically:

- **To what extent are increases in the scale of agricultural activity related to extensive or intensive use of land, chemical inputs, and water?**
- **As agricultural scale economies occur in production, do economies of scale also result for pollution reduction (e.g., waste management in large livestock facilities)?**
- **Conversely, do smaller scale agricultural enterprises face diseconomies in managing residuals, externalities, or waste flows?**

(5) What is the structure of demand for (a) environmental quality as a public good, and the (b) remediation of public bads and externalities from agriculture?

Specifically:

- **If demands that agricultural polluters pay are upheld, should non-enforcement of such measures be considered an implicit subsidy?**
- **Would subsidiarity in responding to environmental externalities create substantial differences in agricultural production costs across countries?**

Appendix Table 4. Detailed Research Issues, concluded.

(6) What is the derived demand from (5) for changes in environmental policy, and how can such policies be successfully coordinated across OECD and developing countries?

Specifically:

- **Is there a role for OECD in advancing more harmonization in agro-environmental policies?**
- **Should OECD seek to assist in the creation of global facilities to respond to trade-environment interactions in agriculture, such as a World Environment Organization or an expanded Codex Alimentarius?**

(7) What technological processes and product characteristics can best promote environmental improvements in agriculture, without interfering with freer trade?

Specifically:

- **Is the product/process distinction capable of being upheld in the face of technological developments such as biotechnology?**
- **If not, can better definitions of agricultural "processes" be developed to establish "green boxes" and "yellow" or "red" boxes where processes are regarded as environmentally damaging?**
- **What impact would regulating processes in this way have on technological innovation in agriculture?**