CHANGING BIODIVERSITY, CHANGING MARKETS
LINKS BETWEEN AGRICULTURAL TRADE, MARKETS AND BIODIVERSITY

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Note by the CEC Secretariat[1]

Overview

While many gaps in knowledge relating to the definition and quantification of biodiversity, as well as the classification and proper identification of species exist, the information that does exist tells a compelling story about the severity of the problem of species loss and loss of biodiversity on the planet. One of the areas of human activity which has significant impacts on species loss and the loss of biodiversity is agriculture.

The purpose of this paper has been to examine some general aspects of the relationship between agricultural trade liberalization and biodiversity and agrobiodiversity, as well as the state of research focussing on this relationship. Clearly, such an examination needs to be more in-depth. At the same time, several tentative conclusions flow from this paper.

The first is that technological change and agricultural trade liberalization are changing patterns of agricultural production and distribution. This pattern is generally away from more traditional, small-scale and self sufficient production, to larger-scale production requiring a shift towards greater amounts of external sourcing of increasingly homogenized farm components. A corollary of the shift towards larger scale, more interconnected agricultural production is the concentration of agricultural production in general into the hands of fewer and fewer players.

The second is that the overall effect on biodiversity of this changing pattern is an empirical question and the subject of some debate. In particular, there remain questions relating to whether the intensification of agricultural production - which it is argued localizes effects and potentially simplifies and lowers the costs of environmental regulation - benefits overall biodiversity.

The third is that while the effect of the changing patterns of agricultural production on overall biodiversity is subject to debate, there is little question that the pattern towards more intensive and interconnected agricultural production is decreasing agrobiodiversity through the replacement of many traditional varieties of agricultural species (both plant and animal) with fewer mass produced and often genetically manipulated, higher yielding agricultural species.

The fourth is that more research is needed to get a firmer understanding of the links between agricultural trade liberalization, changing patterns of agricultural production and distribution, and the effects on biodiversity. This should involve research focussed both on the intensification/extensification debate specifically, as well as on the connections between agricultural trade liberalization and biodiversity more generally. Before such research can be effectively undertaken, however, several challenges need to be overcome, including:

[1] This background Note, by Scott Vaughan and Zachary Patterson of the Environment, Economy and Trade section of the Commission for Environmental Cooperation, has been prepared as a discussion paper for the January 2002 CEC meeting on “Assessing the Environmental Effects of Trade.” Parts of this paper are contained in a draft document, prepared by Scott Vaughan for the Secretariat of the Convention on Biodiversity in late 2000. Views expressed in this Note are not necessarily those of the CEC Secretariat, or of its Parties.

a. limitations involving knowledge on biodiversity itself, e.g. how to quantify it. This requires not only further primary research on biodiversity (e.g. species identification), but also on research which continues in the same vein as the OECD and many other organizations on the development of indicators appropriate to understanding the state of biodiversity, indicators that allow us to answer the question "is biodiversity improving or getting worse?"

b. the incorporation of such indicators into modeling frameworks that have traditionally been used to analyze effects of agricultural trade liberalization on agricultural production patterns, so that this previous work can help also to analyze the effects of trade liberalization on biodiversity.

c. the incorporation of different aspects of agricultural effects that are required to understand the relationship of agricultural trade liberalization on biodiversity, namely land-use change, habitat fragmentation, changes in farm production and land abandonment, changing production methods (technological innovation and efficiency gains, plant genetic resources, agrochemical inputs and pesticides), international transportation (including alien invasive species), as well as socio-economic impacts on farm income and equity and agricultural organization.

Finally, gaps in knowledge and data do not exist only within biodiversity: There are also gaps related to intra-firm trade and their impacts on markets, pricing and environment/biodiversity feedback effects. Intra-firm trade already makes up a significant portion of agricultural trade and production, yet remains outside of most trade rules. Moreover, unlike tariffs and subsidies, intra-firm trade data is not publicly available. Access to such information provides many potential opportunities both for understanding the relationship between trade and environment in general, as well as for the relationship between trade liberalization, the environment and biodiversity in particular.

The opportunity for increased understanding of the relationship between trade and the environment lies in the fact that so much trade now takes place within firms. The opportunity for a better understanding of the relationship between agricultural trade liberalization and the environment more specifically lies in the fact that intra-firm trade itself could be seen as embodying trade in the context of a liberalized environment. Of course, the opportunities would need to realized through cooperating with firms that conduct intra-firm trade.

Introduction:

The relationship between biological diversity and agriculture is complex, dynamic and little understood.[2] Biodiversity provides an essential "input" into many forms of agricultural production, notably providing interactions with species through pollinators, symbionts, pests, parasites, predators and competitors[3]. Many of these interactions are still not clearly understood by science, and almost all are under-valued by conventional economics.

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[2] Although the agricultural sector encompasses fisheries and forestry, this Note restricts itself to examining the *farm sector, and the relationship between crop and livestock outputs* and biological diversity. The relationship between biodiversity and forestry and fisheries, and the effects of trade liberalization on that relationship, continues to be examined in various organizations, including the Commission for Sustainable Development, FAO, WTO, OECD and others.

[3] C.O. Qualset *et al* (1997), "Locally-Based Crop Plant Conservation," cited in D. Wood and J.M. Lenne, (1999) *Agrobiodiversity: Characterization, Utilization and Management,* CABI Publishing, London, pp. 447-470.

In recent years, attention has focused on the state and worrying fate of the world's biodiversity. That concern revolves around estimated rates of extinction for mammals, birds, reptiles, invertebrates, plants, etc. The extent of species endangerment for birds and mammals is well-understood: roughly 11 percent of the world's bird and large mammal species are threatened with extinction. However, that is clearly the tip of the ice-berg: insects, plants and other species are facing the growing threat of endangerment. However, the problem is that the group that is most threatened with extinction is also the least understood, in terms of the biology and distribution of species. Moreover, the order of magnitude of species itself is subject to intense scientific debate: estimates range from 10 million to as many as 30 million species. By contrast, approximately 250,000 species have actually been catalogued by scientists.[4]

Given this gap in knowledge, estimates of the severity of threats facing biodiversity are subject to debate. Estimates on the high end are 1,000 species lost per year, or more than two per day.

What *is* known is that the single greatest source of biodiversity loss is linked to the loss of habitats and ecosystems. For example, the IUCN estimates that habitat loss and degradation affects 89 percent of all threatened birds, 83 percent of threatened mammals and 91 percent of threatened plants.[5] Species rich habitats include rain forests, prairies, wetlands, coral reefs and freshwater systems.

In North America, thousands of protected areas, strong conservation groups, and governmental commitments to maintaining biodiversity are now in place. At the same time, North America has experienced some of the most dramatic landscape transformations and changes in species abundance of any part of the world in the past two centuries. As solutions have been found to transportation, urban settlement, energy and other material needs, the remaining natural environments have been placed under enormous stress. Today, the continent's remaining ecosystems and habitats continue to be fragmented, polluted or damaged in other ways. This decline of habitat, plus specific hunting and harvesting practices, have led to a crisis that is widespread and not confined to any one country or region.

Mexico's wildlife species diversity is ranked as one of the richest "mega-diversity" areas in the world. Mexico also ranks high for endemism. Mexico is the center of origin of many cultivars and other well-known plants. Indigenous cultures of Mexico have succeeded in domesticating roughly 100 species of plants and incorporated over 5000 plant species to cover their most diverse subsistence needs. The positive contribution of Mexican indigenous communities to the conservation of the world's plant genetic heritage is well recognized. So too is the peasant's agricultural practice of basic grains production at the household level, Mexico's traditional means of rural livelihood.

Traditional knowledge is found in indigenous communities as well as in peasant groups. One study in the state of Veracruz showed that peasants are able to recognize the name of 93 percent of the plants, 73 percent of the butterflies and 92 percent of the birds and mammals species of the area. They also understand the different relationships in which these groups of species are engaged.

Mexico's rich biodiversity is exploited for an extensive variety of productive ends, including food, dress, materials for homes and firewood, aesthetic and artistic applications (for handicrafts,

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[4] Marjorie Reaka-Kudla, Don E. Wilson and Edward O. Wilson (1997), *Biodiversity II: Understanding and Protecting Our Biological Resources*, John Henry Press, Washington,.
[5] Jeff McNeely and Sara Scherr (May 2001), "Common Ground, Common Future," IUCN and Future Harvest.

ornamental use and literature), as well as for religious and mystical reasons (sites for worship, amulets, myths and legends).

The preservation and use of crop genetic diversity appears to be of greater importance for more marginal and diverse agricultural environments, including Mexico. Farms in Mexico are typically small – on average one to five hectares – in which diverse crop outputs are produced, some intended for subsistence use, others that enter farm markets. However, research suggests that small-scale and diverse farmers in Mexico are being placed at a competitive disadvantage compared to larger-scale farming operations.[6]

One of the most immediate links between the agricultural sector and biological diversity entails land-use, land use change, and the alteration, degradation or fragmentation of natural habitats. For sometime, agricultural development – together with the conversion of farm lands into urban sprawl – has been recognized as a serious threats to the conservation of biodiversity.

The second general linkage between the agricultural sector and biodiversity entails the extent to which crop varieties form the basis for agricultural output. It is estimated that approximately 7,000 crop varieties are used worldwide to produce food.

However, the shift from complex, multi-species agro-ecosystems -- which typically comprise small-scale and often family owned farms -- to specialized farming raises a number of issues related to crop genetic diversity. Modern, large-scale agricultural production relies on an increasingly narrow and homogenous group of plant genetic resources for the majority of the world's food output. Today, less than 100 species of plants comprise 90 percent of the world's total food crops.[7]

The changing agricultural sector will in all likelihood further entrench the current reliance on this narrow range of crop varieties – including modern varieties that have been genetically engineered – for the bulk of the continent's food supply. Changes in the market structure of the food sector are dramatic. They entail the concentration, consolidation and vertical integration of North America's agriculture sector, in many instances into large-scale, industrial conglomerates. They also entail a significant growth since the North American Free Trade Agreement (NAFTA) in foreign direct investment (FDI) in the food processing sector.

The success of a narrow range of modern plant breeding raises both short term and longer term issues. Increased reliance on modified plant forms poses potential risks about the long-term stability of crop production and the threat of wide-spread and potentially catastrophic plant/pest disease. For example, the main threat to yield stability from modern plant varieties is the increasing uniformity, and continuous cropping, typical of modern varieties.[8]

The image of family-owned, small scale farms – certainly the stuff of Norman Rockwell images – is becoming a relic of the past, at least for specific market segments. This concentration of large-scale, capital intensive food processing industries most pronounced in pig and poultry production,

[6] See CEC. 1999. *Measuring Consumer Interest in Shade-Grown Coffee.* Montreal.
[7] Lori Ann Thrupp (1998), *Cultivating Diversity: Agrobiodiversity and Food Security,* World Resources Institute, Washington, DC
[8] Robert Tripp and Wieneke van der Heide (1996), "The Erosion of Crop genetic Diversity: Challenges, Strategies and Uncertainties," Overseas Development Institute, London.

wine-making, the cattle feedlot sector, irrigation crops such as cotton and other intensive horticulture crops[9].

A divergence thus appears to be underway in the sector, between the kind of large-scale food processing operations noted above, and smaller-scale farm operations. These small scale farms, especially in developing countries like Mexico, typically rely in numerous and complex crop varieties for farm production. However, even within smaller farms, it has been noted that the most important change in modern agriculture entails increasing simplification and specialization of farm-gate production.

Such specialization involves myriad changes in farm production, including a shift to external sources for numerous farm components. As production becomes standardized, one can assume that external components will themselves become increasingly homogenous. At the farm level, th is shift to external sources includes (a) the replacement of subsistence products, in which markets replace production of household farm items; (b) seed stock, in which traditional varieties are replaced by modern, often hybrid cultivars; (c) pest control, in which chemical remedies replace lower impact natural ones; (d) soil fertilizer maintenance; (e) animal feed, in which market supplies replace local production of fodder; (f) labor mechanization replacing household and wage labor; (g) insurance, in which social and market-based insurance replaces the stabilizing or hedging effects of farm output diversity; and (h) changes in land tenure and other institutional provisions.[10]

The effects of the production concentration, market consolidation and specialization are complex to measure on a systematic and aggregate level. In principle, the economic benefits of specialization are often touted by trade economists, and hinge on efficiency gains that are passed along to consumers through lower retail food prices. This in turn contributes to general welfare gains. However, as food markets become increasingly consolidated – roughly 250 significant mergers and acquisitions take place in the US alone each year in the food processing sector – and vertically integrated (research and development, production, transport, marketing and advertising, and retail distribution are under one corporate roof) – some suggest that savings are passed along to processors and retailers rather than to consumers through lower prices.[11]

Measuring the environmental effects of increased concentration and specialization depends. It depend on the agricultural activity involved (there are differences in environmental impacts between cattle feedlots and maize production), on the ecological characteristics of the site in which production occurs, or the scale, technology and other characteristics of the operation in question.

Analysis by Runge and Fox (1999) prepared for the Commission for Environmental Cooperation (CEC) on feedlot production of cattle in the US and Canada notes that the intensification of the livestock sector has led to an increase in the concentration of related pollution. This in turn has shifted feedlot-related pollution emissions from non-point to large scale, point-source pollution

[9] Dennis Henderson (1999), "Between the Farm Gate and the Dinner Plate: Motivations For Industrial Change in the Processed Food Sector," in *The Future of Food,* OECD, Paris.
[10] John Vandermeer et al (1998), "Global Change and Multi-Species Agroecosystems: Concepts and issues," Agriculture Ecosystems and Environment, Volume 67
[11] It is argued that with market concentration, the importance of bulk commodity markets and auction systems decline, there is a shift to increasingly thin market channels, and auction prices become an "irrelevant" reference for contract prices. Henderson, 1999.

sources. This shift in turn makes it easier in principle for environmental regulators to monitor and control pollution, in the same way that regulators can control utilities or smelters.[12]

Similarly, since the 1990s, the number of large-scale poultry farms in the US have dropped from over 800 to around 315. The operations have increased, so that operations typically have 75,000 hens. These commercial operations produce 7 billion egg per year, of which roughly 99 percent is for the domestic market. The environmental effects of commercial eggs farms are significant, particularly as major sources of manure. As in the case of cattle livestock noted above, some commercial egg farms are adopting environmental management systems typically developed for industrial factories.[13]

The "Intensification-versus-Extensification" Debate

Among the most heated areas of debate is the effect of intensive versus extensive farm production not only on the environment and biodiversity, but also on food security and employment levels as well as on the structure of employment. Studies suggest ambiguous outcomes of less intensive, more environmentally friendly agricultural production spread throughout the country-side on the one hand, compared with highly concentrated and intensive production in agricultural bread-basket regions with separate, large-scale nature reserves, national parks and buffer areas on the other.[14]

Advocates of intensive farm production have argued that in addition to meeting increasingly difficult food security demands linked with demographic momentum, it can also be used as an effective means of actually safeguarding biodiversity, since technologically advanced farm production reduces pressure on natural habitats, including for example tropical forests. One estimate is that Central Africa either has to undergo a 4 percent increase in agricultural productivity, or the region's rainforests will be lost.[15]

One way of describing the choice presented above is between either (a) concentrated, modern and highly technified agricultural production, in which biodiversity is expected to be more or less eliminated within the immediate area of production, but preserved beyond that area as no more land is required, or (b) lower-yield, non-technified production which requires more land at the expense of natural areas.

Evidence does show that the adoption of modern agricultural practices, coupled with the creation or expansion of market outlets for traditional crops like coffee, bananas, palm oil, rubber and sugar cane, have contributed to deforestation. For example, the adoption of concentrated technical agricultural production has stimulated deforestation indirectly, by making the conversion of forests into arable lands more profitable.[16]

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[12] C. Ford Runge and Glenn Fox (1999), "Feedlot Production of Cattle in the United States and Canada: Some Environmental Implications of NAFTA," in Sarah Richardson, editor, *Assessing Environmental Effects of the NAFTA,* Commission for Environmental Cooperation, Montreal.

[13] The United Egg Producers note that with large-scale commercial egg production units, eggs are "never touched by human hands from the point of production until finally handled by food service operators."

[14] John Krebs et al, "The Second Silent Spring," in Nature, Vol. 400, 12 August, 1999

[15] I. Serageldin, cited in Arlid Angelsen *et al* (1999), "Technological Change and Deforestation: Definitions, Theories, Hypotheses and Critical Issues," CIFOR Workshop on Technical Change in Tropical Agricultrue, Costa Rica, March 1999.

[16] Barraclough and Ghimire, 1995, cited in Arlid Angelsen *et al* (1999), *ibid.*

While this debate is far from being resolved, some North American consumers have already decided that the health benefits of smaller scale, organic farm produce are preferable to industrial farming. Estimates suggest that the organic farming market in Canada and the United States is growing at between 20 to 30 percent per year, the fastest rate of growth of any farm segment in those countries.) This growth in organic or environmentally-friendly, labeled food products is part of a more general market trend toward product niches. Other examples of product niches include linking of nutrition and human health concerns of consumers, which has prompted industry to market different products (e.g. low fat, no cholesterol), or the marketing of nutriceuticals (i.e. foods that promise medicinal benefits). Of interest is that large food processing companies are aggressively marketing different product niches: each year, between 12,000 to 15,000 new food products – by and large based on variations of the 100 or so major crop varieties – enter markets in industrialized countries.[17]

What is Agro-Biodiversity?

Clearly, the above examples suggest that pressures on agricultural biological diversity will intensify. However, a clear working definition of what is meant by agro-biodiversity remains elusive. A 1998 workshop, entitled "Sustaining Agricultural Biodiversity and Agro-Ecosystem Functions" -- organized by the Secretariat of the Convention on Biological Diversity and the Food and Agriculture Organization of the UN (FAO) – provides an useful insight into the scope of agricultural biodiversity definitions:

> "Agricultural biodiversity refers to the variety and variability of animals, plants and micro-organisms on earth that are important to food and agriculture which result from the interaction between the environment, genetic resources and the management systems and practices used by people. It takes into account not only genetic, species and agro-ecosystem diversity and the different ways land and water resources are used for production, but also the cultural diversity, which influences human interactions at all levels. It has spatial, temporal and scale dimensions. It comprises the diversity of genetic resources (varieties, breeds, etc.), and species used directly or indirectly for food and agriculture (including, in the FAO definition, crops, livestock, forestry and fisheries) for the production of food, fodder, fiber, fuel and pharmaceuticals, the diversity of species that support production (soil biota, pollinators, predators, etc.) and those in the wider environment that support agro-ecosystems (agriculture, pastoral, forest and aquatic), as well as the diversity of agro-ecosystems themselves[18]."

Although the above definition is useful as a normative statement, it provides a weak foundation upon which to undertake trade-related assessments. This conceptual weakness has been explained by the fact that agriculture has been "seriously neglected" by ecologists and conservation biologists until recently.[19]

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[17] Henderson, 1999

[18] Agricultural biodiversity has further been described in the process preparing for SBSTTA-5 to include:

- Harvested crop varieties, livestock breeds, fish species and non-domesticated ("wild') resources within field, forest, rangeland and aquatic ecosystems;
- Non-harvested species within production ecosystems that support food provision, including soil micro-organisms, pollinators, green manures, bio-control organisms and so forth; and
- Non-harvested species in the wider environment that support food production, ecosystems (agricultural, pastoral, forest and aquatic) including landraces, "wild" relatives of crops and livestock, environmental plants such as windbreaks for soil erosion control, etc."

[19] J.M. Lenne, "Optimizing Biodiversity for Productive Agriculture," op.cit.

Given this weak definitional link between agricultural production and biological diversity, it is not surprising that environmental assessments of agriculture are clearest when dealing with indicators of pollution, such as nutrient or other data.[20] Agricultural and environmental coefficients fit more easily when economic data can be tied to quantitative environmental indicators, most of which are pollution related.

Indicators of biological diversity tend to be qualitative rather than quantitative, making it difficult to run economic models grounded in empirical data.[21] This is changing as indicators of biodiversity, as well as agro-biodiversity, improve. During the January 2002 CEC meeting, a supporting paper will be presented by Kevin Parris of the OECD on progress underway in the development of these indicators.

Structural Changes in the Agricultural Sector: Vertical Integration and Foreign Direct Investment

There is little question that trade liberalization – including the North American Free Trade Agreement (NAFTA) and the Uruguay Round of the World Trade Organization – has been an important catalyst for North America's changing agricultural sector. However, it is important to note that other, non-trade factors have important impacts on agricultural markets. At the domestic level, all three NAFTA countries have initiated significant farm policy reforms. The most recent example are the proposed changes to the US Farm Bill. There have also been significant changes in world agricultural prices in the last few years. For example, since 1997-1998, prices for most agricultural commodities have remained well below their levels of the early 1990s. It has been noted that price decreases, which originate from the supply rather than demand side, have led to some strategic shifting among crop production as opposed to an overall decline in agricultural output. Hardest hit by low prices have been the forestry, coffee, cocoa, sugar, palm oil, coconut oil, cotton and natural rubber markets. By contrast, timber and meat prices have remained strong.[22]

As noted, there are also other important structural changes underway in the agricultural sectors in most industrialized countries. These changes involve the consolidation and concentration of market power by commercial agri-food business. For example, four companies in the US have approximately 75 percent of the total market share for wheat flour milling in that country.

Vertical Integration and Foreign Direct Investment in the Food Processing Sector

It is difficult to determine to what extent trade interdependence has supported or accelerated the concentration of North America's agricultural sector. As noted, trade liberalization is one important catalyst in structural changes underway in the sector. It has recently been argued that trade is an increasingly important engine towards vertical specialization among trading partners,

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[20] See for example "Final Analytical Framework to Assess the Environmental Effects of NAFTA," in OECD (2000), Assessing the Environmental Effects of Trade Liberalization Agreements, Paris.
[21] Considerable progress has been made in identifying environmental indicators that are useful in understanding the effects of export trade. However, the Final Analytical Framework developed by the North American Commission for Environmental Cooperation notes that non-pollution, biodiversity indicators remain the weak link in understanding environmental effects of economic policies. See CEC, "Assessing Environmental Effects of the North American Free Trade Agreement," Montreal, 1999.
[22] IMF (October 2001), *World Economic Outlook*, Washington, DC

with countries specializing in distinct stages of the value added production chain rather than specializing in producing one kind of finished good.[23]

This vertical integration is supported both by trade, and more importantly, by foreign direct investment in the food processing sector in North America. Prior to NAFTA, US owned food processing affiliates in Canada and Mexico were substantial. However, since NAFTA there appears to have been an increase in FDI flows in all three countries in this sector. Approximately two-thirds of all food processing affiliates in Canada and Mexico are now owned by US parent companies. Estimated sales of US affiliates operating in Canada have increased from US$5.5 billion in 1987 to approximately $11.5 billion in 1996. Two US companies, Kraft and PepisiCo, represent combined sales of more than $2 billion each. Other US-owned food processing affiliates ranked in order of sales in Canada are Coca-Cola, Nabisco, H.J. Heinz, Campbell Soup, Ralston Purina, ConAgra and Cargill.

Sales from US affiliates operating in Mexico have grown faster than in Canada: estimates suggest sales growth of US$1.6 billion in 1987, to $6 billion in 1996. US parent companies with the largest food processing affiliates in Mexico are PepsiCo, Ralston Purina, CPC International, Kraft Foods, Coca-Cola, Campbell Soup and Pilgrim's Pride.

Although the data is sparse, it would appear that only a small proportion of production output from US facilities in Canada and Mexico are destined for the US market. In Canada, US affiliates exported roughly 9 percent of their total production to the US market in 1996. In Mexico, that figure was roughly 2.5 percent during the same year. The majority of trade in processed food is between the affiliates and US parent companies (that is, intra-firm trade generally exempt from GATT/NAFTA provisions). Consider, for example, Table 1 reproduced frm the OECD.[24] It is a table which presents the Grubel-Lloyd index to measure the amount of trade for different processed foods which is intra-industry. A value of 1 implies that all trade is intra-industry, whereas a value of 0 implies that no trade is intra-industry. Note the extremely high numbers for many of the products, e.g. soft drinks which score 0.999 on the Grubel-Lloyd index. That is to say that a great deal of agricultural trade goes publicly unaccounted for.

Table 1 - US Intra-industry Trade in Processed Foods in 1994 (Grubel-Lloyd Index)

Industry	**GL Index**
Soft drinks	0.999
Preapared meats	0.961
Frozen fruit and vegetables	0.958
Canned fruit and vegetables	0.829
Roasted coffee	0.792
Ready-to-eat cereals	0.745
Cooking oils	0.673
Roasted nuts	0.613
Beer	0.548
Distilled spirits	0.454
Refined sugar	0.394
Pasta	0.282
Wine	0.274

[23] Ayhan Kose and Yi Kei-Mu (2001), "International Trade and Business Cycles: Is Vertical Specialization the Missing Link?", American Economic Review, Vol. 91, May

[24] OECD. 1999. *The Future of Food: Long-Term Prospects for the Agro-good Sector*. Paris.

Cheese	0.253
Flavourings	0.201
Poultry meat	0.031

Canadian FDI into the US food processing sector is also substantial, in the vicinity of US$5 billion. The largest Canadian parent companies with affiliates in the US (1996) are the Seagram/Bronfman family, followed by McCain Foods, George Weston, John Labatt and Cott Corp. Mexican affiliates in the US have also expanded significantly since NAFTA. For example, the largest corn flour producer in the US is Gruma S.A. de C.V., Mexico's largest corn flour and tortilla manufacturer. Other Mexican-owned affiliates in the US food processing sector include Grupo Industrial Bimbo and Minsa, and Alta Verde, a cattle feedlot and slaughter operation.[25]

In addition to changes in affiliates, food markets are converging to some extent on the demand side. While total food demand remains relatively inelastic, income growth in developing countries appears to be stimulating greater demand for meat and processed foods.[26] This may help explain the shift from unprocessed bulk commodities – notably grain, rice and cereals – at lower income levels, to a demand for higher valued added, consumer-ready processed foods – including fruit, meat and dairy produce – at higher income levels.[27]

An additional factor that is creating food market interdependence is a decline in transportation costs. This includes a decrease in the cost of marine transportation, and improved infrastructure for roads and NAFTA transportation highway corridors linking the Canadian, Mexican and US.[28]

Is International Trade Leading to Better or Worse Environmental Conditions?
trade liberalization and agriculture

Given these and other factors, the question is whether free trade is making the conservation of biodiversity easier, harder or much the same.

The agricultural sector is riddled with pervasive and pronounced trade restrictions and distortions. Although the agricultural sector has been subject to various kinds of policy and pricing interventions for centuries, from the 1950s there has been a spiraling increase in trade protection both in industrialized countries, and more recently in transitional economy countries. Typically, trade restrictions and distorting measures applied in the food producing sector includes tariffs, quotas, income support measures, export subsidies, subsidies on productive inputs, decoupled financial transfers calculated other than by output volume, or more recently tariff rate quotas, which have been increasingly applied on sensitive commodities since the Uruguay Round in an opaque manner[29].

[25] Secretary of Agriculture's Report to Congress (August 1997) "The Effects of NAFTA on Agriculture and the Rural Economy," submitted to the US Senate Committee on Agriculture, Nutrition and Forestry, Washington, DC.
[26] UNEP, Sustainability and the Agri-Food Industry, Industry and Environment, Vo. 22, No.2-3, April-September, 1999
[27] John Cranfield et al, "Changes in the Structure of Global Food Demand," August 1998, GTAP
[28] Between 1980 and 1995, world food and agricultural imports increased on average by 5.3 percent per annum. However, rates of growth among different commodity groups varied widely, with processed foods growing at a rate of 8.3 percent over the same period. By contrast, growth in bulk commodities was at a much slower rate, of 2.1 percent per year. Overall, the share of bulk commodities to total agricultural trade declined from 50 percent in 1980 to 32 percent in 1995, while the share of non-bulk products traded increased from half to 86 percent over the same period. Cited in William Coyle et al, "Understanding the Detriments of Structural Change in World Food Markets," May 1998, GTAP.
[29] Thomas Hertel et al, "Agricultural and Non-Agricultural Liberalization in the Millennium Round," World Bank and WTO Conference, 1999 (Revised September, 2000)

In response to this labyrinth of trade restrictions, in the 1990s governments tentatively began a long process towards trade liberalization reforms in the farm sector. The most important expression of this movement towards trade policy reform remains the 1994 Uruguay Round, which included for the first time in the GATT, binding trade liberalization disciplines in the Agreement on Agriculture. Other WTO agreements also have important bearings on opening global agricultural trade, and include the Agreement on Subsidies and Countervailing Measures (SCM), the Agreement on Sanitary and Phytosanitary Measures (SPS), and the Agreement on Export Licensing.

Despite the introduction of liberalization rules, profound trade distortions persist in the agricultural sector. Part of the "built-in agenda" of the Uruguay Round has been to continue the process of trade policy reform in the farm sector, and in March 2001, Parties to the WTO undertook a stock-taking of the current status of the built-in agenda. (See CEC Secretariat Note, December 2001.)

Although agricultural negotiations obviously are moving targets, some argue that the coverage of the Agreement on Agriculture will be broadened, and disciplines related to market access and financial support measures strengthened, and new disciplines introduced to address subsidies, tariff quotas and other distortions.

Of these, farm subsidies remain substantial. Subsidies and other measures have kept input prices artificially low, leading to an often chronic overcapacity and over-supply of domestic agricultural markets, which in turn has led to a series of increasingly complex and opaque measures such as export subsidies, to get supplies into world markets, and high tariffs and non-tariff measures, to keep lower priced commodities from getting into protected markets. Although trade liberalization is not expected to correct all these distortions, it is expected to force inefficient producers -- over time – to leave competitive markets, resulting in a contraction in some producing countries. At the same time, efficient producers, able to compete on international markets will expand production. Put another way, trade reform both creates and destroys markets.[30]

Certainly the most common trade policy observation regarding the effects of trade liberalization on agriculture is that the frequency and actual levels of price-depressing interventions like subsidies and domestic support measures are expected to decline. At the same time, price-increasing tariffs and other measures are also supposed to decline. The counter-balancing price effects which tend to result from the simultaneous reduction in price-suppressing subsidies -- which when lowered reduces overall volumes -- and price-increasing tariffs -- which increases import volumes – can be mixed. For example, reduced levels of trade protection in importing regions increases demand for imported food products, which in turn stimulates trade growth. At the same time, the reduction in export subsidies on exports lowers total supply from some major exporting regions. The aggregate effects of these changes on world supply, prices and changes in trade flows and balances have been described as "ambiguous."[31] At the same time, many analysts have assumed that trade liberalization will narrow the price wedge between domestic and world food prices, leading on average to an increase in farm output prices.[32]

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[30] WTO, 2000.
[31] Thomas Hertel et al, (2000), "Agricultural and Non-Agricultural Liberalization in the Millennium Round,"
[32] Bernard Hoekman and Kym Anderson, "Developing Country Agriculture and the New Trade Agenda," presented to the American Economic Association Annual Meeting, January 1999.

The combined effects of these two liberalization thrusts – which have opposite impacts on price – hinge on the degree to which liberalization lowers the effective rates of trade protection for value added. Modeling assumptions predict the Uruguay Round will lower total level of trade protection from 20 to as much as 40 percent in industrialized and newly industrialized countries.[33]

The Uruguay Round commitments complement liberalization commitments undertaken in the agricultural sector for agriculture. The problem with broad inferences about the assumed impacts of trade policy reform is that they so often run counter to real world evidence. For example, trade theory suggests that world food prices ought to increase, as liberalization occurs.[34] In 1998 and 1999, international commodity markets went in the opposite direction, experiencing a sharp price decline. According to the FAO, the 1998-1999 combined decline in the value of agricultural exports was 22 percent.[35] While average prices declined, changes within individual cereal outputs, by volume, showed uneven and marginal changes:

Table 2 - World Output of Various Cereals 1996-1999 - Million Metric Tonnes

Harvest Of:	**1996**	**1997**	**1998**	**1999**	**Variation**
Wheat	589	613	598	589	-1.4%
Coarse grains	920	905	912	876	-3.9%
Rice (milled)	383	386	390	400	+2.5%
Total	1892	1904	1900	1865	-1.8%

Source: FAOSTAT

Since liberalization also implies the removal of price distortions caused by domestic support or subsidies, trade theory would suggest that liberalization should cause price distortions to decline as liberalization moves forward. Evidence shows just the opposite: a reverse in the downward trend in subsidy support applied in OECD countries. In 1998 and 1999, in response to collapsing world commodity markets, financial transfers in the farm sector increased. In 1999, the combined monetary value of agricultural support policies in OECD countries was US$361 billion, or US$327 per person. The decade long trend towards a reduction in agricultural subsidies has been reversed because of the increases in 1998 and 1999.[36]

This sharp-two year decline represents a combination of several factors, including significant declines in international prices coupled with either flat or absolute decreases in total trade volumes for many key commodities, including coffee and sugar, cereals, oilseeds, oils and fats and agricultural raw materials. (Among the exceptions to this downward price and earnings trend is the international meat market, driven by an estimated 14 percent increase in the value of bovine meat exports)[37]. Other, non-farm factors, have contributed to what FAO terms the "continued, pronounced and widespread decline" in agricultural prices.

[33] GTAP (1997) and Hertel et al, (2000)

[34] Where liberalization is assumed to mean both the removal of trade restrictions (e.g. tariffs, NTBs, etc.) as well as of domestic support (e.g. subsidies).

[35] A preliminary estimate of the total value of global agricultural exports in 1999 was US$146 billion.

[36] OECD Policy Brief, *Agricultural Policy Reform: Developments and Prospects*, Paris, 2000.

[37] A useful tool in estimating probable impacts of trade liberalization are economic models in general, including variations on GTAP (Global Trade Analysis Project) models in particular. GTAP has become a kind of standard agricultural model to assess liberalization. It usually comprises a multi-region, applied general equilibrium model (AGE), in which numerous factors including transportation margins, changes in world savings, changes in investment, and cross-sectoral effects of liberalization can be estimated. Although all models are imperfect, GTAP is reducing duplication of data gathering among researchers, and creating a modeling framework that is available to the public.[37]

A recent GTAP-based study assumes that the Uruguay Round will result in a 40 percent reduction in agricultural tariffs, export and production subsidies. These reductions in turn are expected to increase global welfare by US$ 70 billion. The largest absolute gains from liberalization, expressed in dollar values, accrue to developed countries. The

While most economic literature rightly focuses on the effects of the Uruguay Round on trade in agriculture, NAFTA has also had some effects on regional trade.

As in other sectors, it is often difficult to delineate NAFTA-related impacts of changes to agricultural trade, from changes associated with the Uruguay Round. However, previous analysis has estimated that NAFTA has exerted a modest impact on increasing trilateral agricultural trade in North America. For example, a 1997[38] evaluation highlighted some of the following impacts of NAFTA:

- US agricultural exports to Canada and Mexico grew from US$8.87 billion in 1993 to $11.59 billion in 1996.
- As expected, the largest growth in trade was between the US and Mexico: US exports increased on average by 15 percent per annum from 1993 to 1996. Twelve commodities -- corn, soybeans, what, field seeds, vegetable oils, cotton, sugar and related products, barley, pulses, beef and veal, rice, and soybeans – as a group grew by 150 percent during this period;
- US agricultural exports to Canada grew by 5 percent per year from 1993 to 1996. Twelve commodities – corn, pork, cotton, orange juice, sugar and related products, hides and skins, beverages except juice, soybean meal, wine, peanuts, field seeds and rice – as a group grew by 42 percent during this period.
- The US Department of Agriculture estimates that US exports to Canada and Mexico were 3 and 7 percent higher, respectively, in 1996 than they would otherwise have been without NAFTA;
- US agricultural suppliers hold dominant market shares in Canada and Mexico.[39]

Farm Subsidies and the Environment

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largest relative gains from farm trade liberalization, expressed in contribution to GDP, accrue to developing country regions, in particular (non-India) South Asia and (non-Indonesia) Southeast Asia.

The above reference to the distribution of welfare gains from trade liberalization is broadly complementary with observations that, as price wedges close with the removal of trade restrictions, world food prices will on average increase. This increase in world prices, coupled with the removal of trade restrictions where they are the most pronounced – that is, in industrialized and to a lesser extent in transitional economies – will in turn spur a marginal shift in the location of agricultural production between regions.

Several studies have inferred that trade liberalization will contribute to a contraction in total agricultural production in developed countries, and to an expansion in production in developing countries. When looking at locational changes, two points are worth noting. First, farm production contraction and expansion between regions is well underway. Such changes have been driven not by trade policy reform, but instead by structural and other changes noted above.

More specifically, likely impacts on biological diversity are expected to arise from changes in land use for an expansion in total agricultural output, as well as a shift in the composition of total farm outputs from, for example, grains at lower income levels to processed foods and meat at higher income levels. An extensive body of scientific literature has examined the effect of land use, land use change, habitat loss and habitat fragmentation on species of plants and animals both within the affected habitat itself, as well as adjacent habitats. That body of scientific work clearly shows that land use change and habitat loss represent the most important underlying causes of biodiversity loss.

Since trade liberalization is expected to entrench locational shifts in production that are already occurring in favor of developing countries, the impacts on biodiversity – especially in tropical developing countries – can expected to be high. However, estimating how high – for the reasons noted above related to data scarcities – is very difficult, given both important differences between habitats, together with important differences that different farm production methods have on those habitats.

[38] Secretary of Agriculture's Report to Congress (August 1997) "The Effects of NAFTA on Agriculture and the Rural Economy," submitted to the US Senate Committee on Agriculture, Nutrition and Forestry, Washington, DC.
[39] Secretary of Agriculture's Report to Congress (August 1997), "The Effects of NAFTA on Agriculture and the Rural Economy," Submitted to the US senate Committee on Agriculture, Nutrition and Forestry.

Analysis generally suggests that a reduction in subsidies applied for the most part in developed countries lowers incentives for the over-application of pesticides and fertilizers, lower pressures on the conversion of vulnerable or ecologically significant lands into arable production, and lowers other kinds of production pressures, including irrigation withdrawals.

At the same time, the impact of subsidy reduction is likely mixed. For example, concern has been raised about reducing all types of financial support in the farm sector – including decoupled farm payments – on greenbelt areas, landscaping objectives and land set-aside initiatives. In addition, the withdrawal of subsidies may spur farmers towards higher levels of economic and production efficiencies, including concentrating production intensities and altering crop outputs. Evidence from NAFTA suggest that trade liberalization has led to the concentration of very large scale, or factory-type, livestock production areas as a means to lower production costs and remain competitive[40]. The environmental impacts of larger scale meat production are significant, and are described below. Evidence also suggests that with a reduction in subsidies, farmers may move production towards higher-value outputs like horticulture. These higher value outputs generally require large volumes of agro-chemical inputs.

Part of the difficulty in making clear pronouncements about the impacts of subsidies reduction is the difficulty in weighing trade-offs between local environmental and biodiversity-specific costs, and economic benefits that accrue from liberalization at an aggregate level. These benefits revolve around general welfare associated with more open trade policies. Trade theory and empirical studies suggest that countries that adopt open trade policies experience higher rates of economic growth on average compared with countries that maintain closed trade policies[41]. As an important engine of economic growth, the net effect of trade liberalization is an absolute increase in merchandise trade flows. A corollary effect may be increased flows in foreign direct investment.

Slightly less complex than estimating quantitatively the effects of subsidies removal on biodiversity, is estimating the relationship between trade policy reform and conservation policies. As a *policy-to-policy* analysis, several consensual points have emerged from the trade-environment debate. Foremost among them is that, although impacts of subsidies removal are uneven in some instances, reducing farm subsidies as well as other price distortions raises the potential effectiveness of environmental policies. While trade policy reform is capable of correcting some government failures that undermine agro-environmental management and conservation objectives, it cannot be seen as substituting for conservation policies.

[40] R. Ford Runge (1999), "Feedlot Production of Cattle in the United States and Canada: Some Environmental Implications of the North American Free Trade Agreement," in *Assessing Environmental Effects of NAFTA*, North American Commission for Environmental Cooperation, Montreal.

[41] A standard definition to measure open and closed economies does not exist, although several methods have been used. These include measuring the average tariffs, the percentage of tariffs covered by non-tariff barriers, an index of structure adjusted trade intensity, the application of the Leamer measure of openness and trade distortions (which measures the deviation of total trade volume from its theoretically predicted value), and Dollar's measure of price distortions. Other barometers of openness include tariff and quota rates applied on intermediate and capital goods, black market foreign exchange premiums, and the existence of export marketing boards. One study (Frankel and Romer, 1996) suggests that, in separating important non-trade variables, countries that trade more also enjoy higher per capita incomes than countries that trade less. (Jeffrey Frankel and David Romer, "Trade and Growth: An Empirical Investigation," in NBER Working Paper No. 5476, National Bureau of Economic Research, March 1996, cited in Michael Ferrantino et al, *The Dynamic Effects of Trade Liberalization: An Empirical Analysis*, US International Trade Commission, October 1997.

Given the magnitude of market failures in the farm sector, coupled with the severity of biological diversity loss that requires more robust public policy leadership, trade liberalization is seen as an important, but insufficient, step towards strengthening some environmental policies, mainly by virtue of eliminating offsetting effects of trade distortions.

A closely related question is the relationship between trade rules – intended to secure price-neutral trade measures – and domestic conservation and sustainable use policies. The Green Box exemptions contained in the existing WTO Agreement on Agriculture include provisions related to environmental and conservation objectives. During the current review of the Agreement on Agriculture, if the Green Box exemptions are revisited in light of recent developments in conservation polices – including for example land easements, tax credits for set-aside or other measures, or regulatory measures aimed at habitat and species protection – then the SBSTAA may wish to consider providing advice to the WTO on best practices in conservation and agro-environmental measures.

Sustainable Use Goals and Trade Rules

Different types of issues arise when looking at the relationship between sustainable use and trade liberalization. It would appear that trade liberalization supports the adoption of more concentrated, modern and specialized agricultural production methods over more traditional, lower impact farming. That is, as international farm markets become more contestable with liberalization, pressure increases to improve production efficiency. Trade policy assumes that comparative advantage is equally applicable in all sectors, so that efficiency gains from scale economies also equally to the farm sector as they do to the manufacturing sector. Recall the heated debate around extensification and intensification where those in favour of intensification argue that by concentrating livestock production in very large, factory type environments, production concentration changes emissions from non-point source to point-source, thereby making monitoring and regulatory enforcement easier.

However, this concentration in scale economies has important and direct impacts on biodiversity within the immediate location in which large scale production occurs. For the most part, plants and animals living within a habitat that is converted to large scale, modern farming practices are eliminated from that habitat. This makes the immediate impacts of modern farming on biodiversity overwhelmingly negative. And while trade liberalization would appear to support modern agricultural production, the opposite is not necessarily true, that trade liberalization *discourages* less intensive farm production methods such as agro-forestry, organic farming or integrated pest management.

An area that has been examined for sometime, without a satisfactory clarification, concerns the relationship between market-based tools like environmental labeling and certifications, which are intended to differentiate products produced with lower-impact production methods, and trade rules. For example, while the performance of "green labels" has remained largely flat in most countries, there is evidence of increasing consumer interest in various kinds of certified food products intended to convey to consumers information that touches on different aspects of sustainability. In North America, more than 50 food labels related to organic, conservation or fairly-traded agricultural products are competing for a market niche estimated to exceed US$100 million per year, with rates of growth of 20-30 percent per year.

Given the very strong relationship between sustainable use and methods of agricultural production which do not reply on modern, large scale and industrial type of farming methods, it remains unclear to what extent labels and certification schemes would fit with WTO provisions related to labeling, including provisions contained in the Agreements on Technical Barriers to Trade (TBT) and SPS provisions. Given the nine-year discussions that have taken place, and continue, in the WTO (and before 1995 in the GATT), on the issue of environmental labeling, it is not the intention of this Note to do anything other than point to the continued ambiguity of this relationship.

I. Trade-Related Changes in Farm Production Location

Trade liberalization is expected to influence a change the location of agricultural production between regions. In general, a contraction in agricultural production may be expected in countries that currently maintain the highest levels of trade protection – that is, industrialized and some transitional economies – and an expansion in agricultural production n developing countries. The most significant biodiversity-related impacts resulting from changes in the location of farm production center around the question of land use change.

S noted in Section One, different estimates have been mooted regarding the extent and likely pattern of production shifts associated with trade liberalization. One study (1994) estimates an overall contraction of 5 to 6 percent in total grain and meat production in developed countries, and a 3-8 percent expansion of meat production in developing countries.[42] The issue examined in the remainder of this sub-section is the probable impact of locational shifts on land use and land-use change, both in developing and developed countries.

A. Land Use Change

Most analysis of the environmental effects of trade-induced shifts in the farm sector have concentrated in *production* issues. Two issues warrant closer study: what are the impacts on biodiversity, associated with an expansion in farm production in developing countries? And what are the impacts on biodiversity of a contraction in farm production in developed countries?

From the perspective of potential changes in biodiversity, it is the first question that clearly is more important, for two reasons. First, an expansion in farm production will have immediate impacts on land use and land use change. The extent of that change in land use depends on the type of crop and crop production method introduced. In general, examples of land use change associated with the farm sector have included the clearing of primary forests – including tropical forests – for arable lands, and the conversion of natural prairies and grasslands for crop growing or livestock grazing, as well as the draining of wetlands either for irrigation or land conversion purposes. For example, the loss of most grasslands in North America in the latter part of the last century has been linked primarily to increased cropping, mainly wheat production[43].

A useful framework in which to examine land use change and its impact on biodiversity is to distinguish between land cover and land use. Land cover refers to the habitat or vegetation type present, such as for instance forests, wetland, grassland, wild prairies or – more commonly in developed countries – urban centers and increasing sprawling suburbs and industrial mini-centers. Land use refers to the manner in which humans make use of the land and its resources, including for forestry, farming, housing or recreational areas or protected parks. (ibid, 37)

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[42] K. Anderson and R. Tyers, *Disarray in World Food Markets: A Quantitative Assessment,* Cambridge University Press, 1992

[43] Monica G. Turner et al, “Land Use,” in United States Geological Survey (1998), *Status and Trends of the Nation’s Biological Resources,* Washington, pp.37-62.

Turner *et al* have identified three ways in which land use change affects biological diversity. First, land use patterns alter the relative abundance of natural habitats and result in the establishment of new land-cover types. The introduction of new land-cover types in turn affects the variety of species, by changes made in the size and variety of habitats.

Second, the spatial pattern of habitats are altered by land use, and these changes can result in the fragmentation of a once-connected or continuous habitat. Examples of habitat fragmentation of relevance to this Note's topic include the creation of large crop-growing or cattle grazing areas, or the building or enlargement of roads or other infrastructure systems. The impacts of habitat fragmentation on biodiverswity are direct, often profound and numerous.

Third, land use can alter the natural pattern of environmental variation, including causes changes in natural disturbance patterns, notably extending the boundaries and duration of natural fires, or increasing flooding.

Although these general effects are now well established, it remains difficult to estimate precisely the extent to which land use change affects biological diversity, since data and other gaps remain about the impacts of habitat contraction, fragmentation or destruction on plants and animals. However, it is now clear that the relationship between changes in land us and changes in biodiversity are not necessarily proportional, and that *big effects can arise from small causes* (Ricker, 1963, US, p. 55). That is, the accumulation of small changes in land cover linked to land use poses the greatest challenge in implementing biodiversity conservation programs.

Land use is altered by many factors, including the expansion of farm-lands, raising of livestock, forest harvesting, the draining of wetlands for agriculture[44], the use of irrigation for dry croplands, and land conversion for urban areas. In addition to direct land use changes, it has been noted that changes in drainage and erosion that accompany agriculture have important impacts on rivers and lakes, biodiversity contained within them, and the plants and animals that rely on access to fresh waters.

Among the most important causes of biodiversity loss relates to changes in forests, and an extensive body of literature exists linking the conversion of forest cover into arable lands, and magnitude of species loss associated with losses in primary forests. Animal communities are negatively affected not only by the removal of forests, but also by the patterns of forestry re-growth.

Given the important links between land use and agriculture, the particular question is the extent to which trade liberalization affects land use. As noted, many studies suggest that the general impacts of trade liberalization will be a relative contraction in agricultural production in developed countries, and a relative expansion in agricultural production in developing countries. The ratio of contraction and expansion is asymmetric, because of the following variables.

- A shift in land use, within the same product category, but using different agricultural production methods
- A shift in crop use, for example from low value to high value crops, within the same land area, although using different production methods

[44] Between 1780s and 1980s, approximately 53 percent of all wetlands located in mainland United States were converted to other uses, and between 1950s and 1970s, nearly 4.5 million hectares of wetlands were lost. Meyers, 1995, cited in USGS, p. 39)

- A shift in productive resources from agricultural to other types of production, for example, a shift in labor markets from agriculture to the manufacturing sector, leading to several challenges, including urban migration and urbanization

B. Habitat Fragmentation

While the absolute destruction of a habitat will suggest the elimination of species that rely on that habitat, habitat fragmentation also exerts numerous and negative impacts on biological diversity. For example, fragmentation can lead to the loss of a species in single habitat patches as well as the loss from the regional landscape.

The fragmentation – or loss of connectivity – of a habitat depends on its abundance and its spatial arrangement. These impacts have been well documented[45] For example, studies suggest that smaller forest patches also have fewer nesting bird species within the remaining patches, while after a certain size certain species – often insect-eating birds -- were very unlikely to remain within the patch. Species that rely on tracks of old-growth forests find themselves under increasing stress, as old growth forests disappear.

For example, when forests are fragmented, forest birds may experience higher rates of parasitism by other species. Changes in bird abundances are also strongly correlated with changes in early successional and forest cover.

Even when discussing extensively documented areas like correlations between forestry loss and species loss, the particular chain of events that connects the loss or fragmentation of a habitat with the loss of an individual species is not clearly understood, aside from the fact that unexpected events can occur from the loss of a single species. For example, the abundance of a single species can change because of land use change and habitat loss or fragmentation. Changes in the abundance of one species often has complex and unforeseen impacts on potentially hundreds of other species, situated not only within the affected habitat that has become fragmented, but also for species situated outside of the affected habitat.

Put simply, land use change initiates a series of events that are often profound, and which may not be clearly understood because the connections that link habitats with biodiversity are themselves not clearly understood.

C. Contraction in Farm Production and Land Abandonment

Biodiversity-related impacts associated with a contraction in productive lands are generally assumed to be positive over time, assuming effective environmental and conservation policies are in place to manage idling or abandoned lands. At the same time, no recovery can occur for species that have become extinct because of habitat loss linked with the expansion in agricultural production, and recovery is not expected to return abandoned lands to their natural state prior to the conversion into arable lands. The historical record may provide some valuable insights into the extent to which habitats recover following farm production abandonment.

As farm production expanded between the 1800s and 1930s, forests were cleared almost continuously, so that more than 80 percent of the original Piedmont cleared at least once. As farming became unprofitable in the many parts of Eastern United States beginning in the mid-1800s and up to the late 1930s, many farm lands were abandoned, and forests gradually grew

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[45] Saunders, 1991, cited in Monica Turner, op. cit.,

back on neglected fields. This recovery lead to the broad-scale re-establishment of forest cover over much of the northeastern U.S. However, virgin forests – mainly pine – were decimated during the land clearing, and today approximately 2 percent of all forest cover remains the original longleaf pine forest. Most of the abandoned farms reverted through a succession of pine (primarily loblolly pine and short-leaf pine), and there is evidence that some forests are now making a transition to broadleaf forest (Turner, 1990, cited in USGS, p. 41)

Evidence suggests that while forest cover may be stabilized or on the increase in some countries, as trees begin re-growth in abandoned fields, forested habitats my not be a suitable habitat for some bird or other species, compared to forested habitats of pre-settlement and agricultural production periods. For example, the shift from deciduous forests to pine forests do not appear to allow for the re-introduction of forest under-story wildflowers and birds such as the red-eyed *vereo* in North America. (USGS, p. 49)

It is also worth noting that assumptions about trade-related allocative efficiency, which have taken hold for the manufacturing sector, may create distinct problems in the agricultural sector. That is, the specialization of production based on comparative advantage concentrates that production within a specific area. In addition to the output-related problems described above, it does not take into account the overexploitation of finite resources within an ecosystem. It has been noted (Runge, 1993) that when a country is endowed with a resource that is locally abundant but globally scarce, then a more efficient allocation of resources would be to conserve rather than trade that resource.

Among the reasons for this asymmetric relationship is that factors of production are obviously not static within and between countries. For example, comparative advantage in the farm sector is increasingly associated wit the specialization of production to achieve scale economies. This specialization in turn is often characterized by the adoption of modern agricultural production methods, which include a geographic concentration of farm production, the use of a very narrow range of plant genetic resources for crop output, the conversion of lands for large-scale farm production, and the use of various capital inputs – including agro-chemical inputs – to maximize yield.

Clearly, other policies besides trade liberalization affect the environmental impacts of land conversion at least as much, and more than trade policy reform. These policies have been studied extensively, and include the nature of incentives in place for land clearing, or forest-access issues, including the incursion of roads and other transport infrastructure systems into virgin, natural areas, so as to deepen the access of agricultural producers to resource-rich areas.   Attempts to disentangle the effect these policies exert at the local level, as opposed to the pressures of macroeconomic policy, in terms of assigning causality and estimating effects, remains difficult if not impossible.

II. Changing Farm Production Methods

As the agriculture sector becomes restructured around principles of comparative advantage associated with trade liberalization, farm markets become more contestable at the international level. Producer responses to increased market contestability generally involves increased efficiency in methods of production. There are a number of ways in which production efficiency is enhanced in the agricultural sector, but perhaps the most relevant to the subject matter of this Note is the adoption of more technologically-efficient production methods.

A. Technological Innovation and Efficiency Gains

Technological progress is usually defined as a net increase in total factor productivity. This can be achieved in two different ways: first, more physical outputs are achieved with the same amount of inputs, or second, the same amount of physical output is achieved with fewer inputs.[46] Technological progress can also be regarded as the extent to which the adoption of more efficient production methods increases net profit. (ibid) Estimating the relationship between production technologies and net profit in the agricultural sector is probably more complex than in other sectors, given the important influence of non-technological factors exert on net profit, including price volatility factors. Technological change and production efficiency gains in the agricultural sector often concentrate on agricultural intensification, that is, the manner by which higher output is achieved per hectare of land.

Given the wide variation in farm methods and crop/livestock outputs, it is difficult to examine precise impacts on biodiversity, except in a general manner. A recent study estimates that efficiency gains expected to accrue in different regions from liberalization of the agricultural market, and have found that the largest efficiency gains occur (not surprisingly) in Western Europe, in which an estimated 40 percent reduction in trade restrictions leads to an 8 percent increase in the region's value-added segment of the entire food sector. At the other end of spectrum are efficiency changes in Australia and New Zealand, which are expected to decline marginally, which is expected to occur because of a large increase in dairy exports[47].

B. Characteristics of Modern Farm Production Methods

Farm production modernization is often characterized by more intense land tillage, including tillage of sloping areas; an increased reliance on freshwater inputs, including irrigation, which often exert water quality and quantity effects; the adoption of monoculture crops in support of specialization objectives; the concentration of livestock operations; and reliance on agro-chemical inputs. Although all farming representing the conversion of natural resources and changes in habitats, technified, concentrated, specialized and large scale farm production tends to push wildlife outside of the farm system. Pesticide and other agro-chemicals, which by intent destroy target species, and by accident disrupt or destroy non-target species. Soil compaction causes water to infiltrate the soil differently, which may increase the risks of runoff and erosion. Nutrient cycles can be significantly altered, as nutrient-based fertilizers bring about changes in soil bacteria and vegetation[48].

C. Plant Genetic Resources for Food and Agriculture

The domestication of crop varieties and animal breeds for food production has been underway for thousands of years, obviously long before the advent of formalized trade liberalization initiatives. From very early on, farmers selected from a narrow range of plant families and animal genera in specific geographic locations, in which to concentrate domestication. While the major trajectory of farm production has been the continual narrowing of crop selections, farmers have often revisited wild varieties to make use of certain characteristics.

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[46] Arlid Angelsen et al (2000), "Technological Progress and Deforestation."
[47] Thomas Hertel, Kym Anderson, Joseph Francois and Will Martin (2000), "Agriculture and Non-Agriculture Liberalization in the Millennium Round," revised paper presented to the Global Conference on Agriculture and the New Trade Agenda, WTO and World Bank, Geneva, October, 1999.
[48] World Resources Institute, *World Resources 2000-2001*, Washington, 2000.

Agriculture has allowed crops and livestock to spread beyond the range of their wild ancestors, which in turn has exposed them to a much wider range of environments.[49] Perhaps the most visible example of plant domestication is wheat, which resulted from a cross between *Triticum turgidum* and *Triticum tauschii*, resulting in the transformation of an ordinary cereal into the most widely used food staple on earth. From an origin in the Near East, bread wheat is grown in the Americas, Africa, Asia and Australia.

More generally, and according to the FAO, there are between 300,000 and 500,000 species of higher plants (that is, flowering and cone-bearing plants), of which approximately 250,000 have been identified or described. However, a far smaller range of plants -- roughly 30 crops -- provide an estimated 95 percent of the bulk of the world's total dietary energy or proteins. Wheat, rice and maize provide more than half of global plant-derived energy intake. A further six crops or commodities – sorghum, millet, potatoes, sweet potatoes, soybean and sugar (cane/beat) – raise the total energy intake to 75 percent[50].

According to the FAO, one of the main causes of increased risk of genetic vulnerability is the widespread replacement of genetically diverse traditional or farmers' varieties with homogeneous modern plant varieties. A key concern related to a reliance on a narrow range of plant varieties for total food output is higher risks of genetic vulnerability, that is, when a widely planted crop is susceptible to a pest, pathogen or environmental hazard, leading to the possibility of sudden and widespread crop losses.

The opening of domestic markets to international demand, coupled with modern farm production, also places increased pressures on exhaustible natural resources linked with agricultural production -- including for instance soil nutrients which are exported with farm outputs. [

D. Agro-Chemical Inputs

Among the characteristics of industrialized or homogeneous factors of agricultural production is an increased reliance on fertilizer and pesticide inputs.

In 1998-1999, total fertilizer consumption was approximately 91.5 million tons. This compares to slightly more than 26 million tons in 1960-1961, and 78 million tons in 1980-1981[51].

Data on world fertilizer that aggregates the three main fertilizer categories – phosphate, (P205), potash (K20) and nitrogen (N) – shows important shifts in fertilizer demand since 1960. In that year, approximately 88 percent of world fertilizer consumption occurred in developed countries. By 1998-1999, fertilizer consumption in developing countries amounted to 61 percent. The increase of nutrient consumption developing countries has been especially pronounced, to the point where impacts on soils from an over-use of nutrient inputs has been described by the fertilizer industry itself as "severe." (ibid)

Among the most studied impacts of intensive fertilizer application involves eutrophication, a gradual increase in the concentrations of phosphorous, nitrogen and other nutrients, primarily into aquatic systems. Debate continues about the main sources of eutrophication, although it is widely recognized that agricultural run-off coupled with soil erosion are important sources. The effects

[49] Lenne and Wood,
[50] (FAO, State of the World's Plant Genetic Resources, 1998)

[51] International Fertilizer Industry Association, Statistics, 7 June, 2000.

of increased nutrient and other loadings into rivers, streams and lakes vary, although eutrophication is generally linked both to algae blooms and oxygen absorption. In addition, nitrate entering the food-chain can have adverse effects on wildlife and humans.

Data on total pesticide consumption appears to be more difficult to obtain than that for fertilizer use. Pesticides comprise a category of mainly toxic chemicals, intended to maximize agricultural productive yields by killing animals and plants – mostly insects and weeds – that interfere with production. Pesticides interfere with normal metabolic processes.

Worldwide, an estimated 4-5 billion pounds of pesticides are applied yearly, with rates of use having increased sharply in the last twenty years.

The effects of pesticides on the environment and biological diversity, and on human health, have been the topic of intense study and debate. Typically, hundreds of different categories of pesticides are applied in different environments. While tests are performed on individual pesticides, considerable knowledge remain about the combined, incremental and longer-term impacts of pesticide on biodiversity.

Estimating the overall impacts of pesticides is difficult, given the considerable variation that exists between different products in toxicity, persistence or the tendency to bioaccumulate. For example, some pesticides exhibit relatively low levels of persistence – roughly 18 months for 2,4-D and atrazine --- while others persist on average for up to 20 years. Recent studies suggest that pesticides have impacts well beyond their immediate insect or pest target, to affect almost all aspects of the ecosystem in which they are applied or to which impact occur. Pesticides are also giving rise not only to pesticide-resistant pests, but also to pathogens and weeds, as well as leading to a dramatic decline in populations of natural enemies. Pesticides have also been shown to affect the decomposer system and soil conditions and nutrient turnover. (p. 306)

E. Impacts of Pesticides and Other Chemicals on Non-Target Species

The effects of trade liberalization on agro-chemical use tend to be mixed. That is, while liberalization appears to support greater production specialization and concentration, studies also suggest that a decline in producer price support and other subsidies, is strongly correlated with a decline in the total application of agricultural chemicals. For example, one study has found that a 50 percent reduction in subsidies results in a 17 percent reduction in pesticide use and a 14 percent decrease in fertilizer use. The same study also finds that the complete elimination of subsidies would result in a 35 percent reduction in total chemical use per acre, and a 29 percent reduction in fertilizer use per acre[52].

Pesticides exhibit both lethal and non-lethal impacts on non-target species, both within the targeted area, as well as affecting non-farm habitats. Organophosphates do not tend to bio-accumulate or persist, while certain other pesticides – including carbofuran, diazinon, parathion, chlorpyrifus and phorate – exert much more harmful effects on wildlife. Synthetic preythroids have been shown to be less toxic to birds and mammals, but extremely toxic to fish and other aquatic species[53]. In general, wildlife is exposed to pesticides in two ways: (a) animals are directly exposed to a toxic pesticide during spraying, and ingest the chemical directly by

[52] Jonathan Tolman, "Federal Agricultural Policy: A Harvest of Environmental Abuse," in Competitive Enterprise Institute, 1995

[53] The toxicity of a pesticide to animals is expressed as either LD50 (lethal dose) or LC50 (lethal concentration. Dale Rollins et al, "Reducing Pesticide Risks to Wildlife," Texas National Resource Conservation Commission.

breathing or swallowing, as well as through absorption through the skin. Birds sprayed by pesticides can die, or show a tendency to neglect their young, abandon nests, and become more susceptible to predators and disease.

And (b), wildlife can be indirectly affected by pesticides through the food chain. For example, some studies show a negative correlation between game-bird populations and insecticides. Moreover, birds and other wildlife have a more difficult time obtaining nutrition (eg insects) in areas that have been sprayed with insecticide.[54]

Birds are an illustrative taxon of pesticide effects. One study has found that bird populations in sun-grown, technified coffee plantations were as much as 90 percent lower than in canopy-grown, agro-forestry coffee plantations [55]. Another study has found that 10 percent of birds exposed to the roughly 900 different types of pesticides applied in the United States -- approximately 60 million birds – die. Species especially susceptible to pesticide damages include bald eagles, osprey, brown pelican, green-winged teals, red-tailed hawks, chipping sparrows and Peregrine falcons. Non-lethal effects of pesticides on birds include eggshell thinning, reduced ability to maintain weight, and other adverse effects. (US National Fish and Wildlife, cited [in]

While pesticides have raised environmental concerns about negative effects on wildlife, concern about human health effects dominate public debate and policy. Concerns center around risks pesticides pose to farm workers, and in particular their children, exposed to pesticides during handling and application. Pesticide residues are found indoors in many farm households, and exposure of certain pesticides – in particular organophosphates and carbomates – has been linked to various negative human health effects. Studies have determined strong links between exposure to pesticides and cancer, as well as (for example) the impacts that organic-phosphate chemicals may pose to children.

IV. International Transportation

One of the outcomes of trade liberalization is an increase in production specialization, coupled with the dispersion of production units to geographically diverse and often distant locations. An important reason why export trade has increased is because of improvements in transportation systems.

Put another way, while most export trade analysis concentrates on the impacts of lowering various artificial barriers to international trade, including tariffs, quotas or subsidies, improved transportation has progressively led to the reduction in natural barriers to trade, partly through a reduction in transport costs. Traditionally, international trade has concentrated on high value to weight ratios. However, average tonnage of ships has increased, supporting infrastructure has lowered various port costs, which is allowing for greater export trade in lower value to weight ratios, including increased shipments of low to mid-value farm outputs (in addition to higher value agricultural produce).

It has long been noted that the construction of rural roads in developing countries, in particular tropical developing countries, brings with it paradoxical costs and benefits. Roads play an important role in land-use change, by affecting not only the immediate land that is transformed for road construction, but by affecting the relative input prices and agricultural output prices of lands adjacent to the rural road expansion.

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[54] William Palmer et al, "Wildlife and Pesticides: Corn," North Carolina Extension Service.

[55] Smithsonian Migratory Bird Center, cited in Commission for Environmental Cooperation, 1999 [get citation]

Among the benefits of road construction is that it is an important tool for rural development, which directly assists the rural poor by increasing access to markets. At the same time, various environmental and biodiversity-related costs are associated with rural road construction. These include changes in land-use from infrastructure creation or expansion, and the possible degradation of forests, wetlands and wildlife migration corridors that may be associated with expanded road, rail, waterway and other transportation systems.

For example, studies at the field level have shown various environmental costs linked with road building. These include a strong correlation between road building and deforestation. Other observations include:

(i) market access and distance to roads is strongly affect the probability of agricultural use, especially a correlation between distance to roads and the adoption of commercial agricultural practices;
(ii) a strong link can be found between access to infrastructure and the rate and type of environmental degradation;
(iii) high slopes, poor drainage and low soil fertility discourage commercial agricultural practices, as well as semi-subsistence farming[56].

The impacts of increased agriculture more directly on biodiversity can be seen from the strong links between road extension, and habitat fragmentation. Studies suggest that the long-term impacts of roads on a species population and rate of growth is not clearly understood, and requires more study in the filed. However, studies do clearly show that roads often act as effective barriers to the movement of animals, in particular invertebrates and smaller vertebrates. For example, the construction of roads and/or parking lots has been shown to lead to the complete division of some populations of ground beetles (Mader, 1984, cited in USGS, p. 52) Larger wild animals have also shown to be adversely affected by road construction, and have been shown to act as significant barriers to migration, as well as an important cause of death either by accident, or by increased access by poachers to natural habitats.

A. Alien Invasive Species

Although most of the impacts linking export growth to biodiversity are secondary or indirect – that is through indirect effects of shifts in relative prices –m the most important exception to this observation is alien invasive species. While the trade-environment debate has settled into an assumption that trade in itself has no direct environmental links, this is not true when dealing with among the most important causes of biodiversity loss, alien invasive species.

CHARACTERISTICS OF INVASIVE SPECIES[57]

- high rate of reproduction; pioneer species; short-generation time
- long-lived
- high-dispersal rates
- single-parent reproduction (for example, a gravid or pregnant female can colonize)
- vegetative or clonal reproduction
- high genetic variability

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[56] Kenneth Chomitz (1995), "Roads, Land Use, Markets and Deforestation: A Spatial Model of Land Use in Belize," in World Bank, Staff Working Paper Number X.
[57] US, p. 119

- phenotypic plasticity
- broad native range
- abundant in native range
- tolerant of wide range of conditions
- habitat generalist
- broad diet (polyphagous)
- gregarious
- human commensal

With considerable justification, the problem of non-indigenous species is placed high on the biodiversity agenda of the US in particular. The Office of Technology Assessment (OTA) in 1993 estimated that documented economic costs of dealing with 79 taxa over the course of this century had reached at least USD 97 billion. This is far below the actual cost to the society since the number of harmful introduced life forms is much larger, and many costs, for example, of some agricultural weeds were not included for lack of data. Aquatic invaders can be very costly, as we known from the case of the tiny zebra mussels that clog intake pipes at power generation stations (OTA estimates costs on the order of USD 3 billion over this decade). The concern is driven by a wide variety of interests, for example, bee keepers who fear economic losses arising from hybridization of African colonies with managed European honey bees used for pollination; fishers in British Columbia and west coast states who fear that Atlantic salmon escaped from aquaculture cages will displace stocks of threatened Pacific salmon; public health specialists who worry about disease vectors such as aquatic snails now introduced into the southern US that could become hosts for schistosomiasis; and state governments forced to deal with aquatic weed control problems in waterways and drainage ditches.

The effect of invasive non-native species on biodiversity is the outright and often dramatic loss of native species.[58] This loss takes place in different ways, and can include either new, non-native species directly forcing out native species, either through a change in the basic structure of the ecosystem invaded, or through a shift in ecosystem dynamics, such as an alteration in the food-chain. Observed impacts include invaders displacing native species outright through competition, decreasing the availability of food, change the characteristics of sunlight penetration in forest canopy areas, displacing native vegetation and altering habitat structures.

Bio-invasive species commonly also have cascading impacts throughout an ecosystem's food web, where the introduction on non-native species can induce important shifts in a local food chain, forcing out native species. (ibid, p. 122)

For centuries, the problem of biological invasion – which generally refers to the movement or introduction of a species beyond it native range – has existed. However, pathways allowing the unintentional introduction of invasive species have expanded, through trade in agricultural products, cut flowers, timber, seeds, potted plants, ballast water and other routes[59]. Estimates vary about the numbers of non-native species that have been introduced to other ecosystems. A recent estimate suggests that more than 6,500 species of non-indigenous animals, plants and microbes exist in the United States alone (ibod). Estimates also suggest that between 5-10 percent of introduced species become established, and between 2-3 percent are able to expand their ranges.

[58] United States Geological Service (1998)
[59] ibid.

A recent study has warned that the accelerating homogenization of the world's flora and fauna, which is the result of millions of years of evolution, is nothing short of an "ecological holocaust." (ibid) Given the scale and speed with which thousands of species are being transported each day around the globe, through the ballast water and holds of ships, in agricultural produce, in airplanes and trucks, native biotic communities are often unable to defend themselves against the sudden introduction of new species. Scientific studies have found that the invaded community is unable to recognize the non-native species that has arrived, and is often without natural controls to prevent the establishment of the invader. The invasion of non-indigenous species has thus been compared to "an ecological surprise attack," with the most severe impacts probably not understood until well after the species has become introduced into a non-native habitat.

Export growth in the agricultural sector is likely to result in the expansion of international transportation, and with it the creation of new pathways for alien invasive species. Indeed, growth in the movement of people and goods, coupled with briefer travel time between destinations, allows not only more non-native species to become introduced into other ecosystems, but – because of those shorter time periods – to increase their chances of surviving in new systems.

As noted, the ecological costs of invasive species can be devastating. Estimates suggest that non-indigenous species have been responsible for the extinction of at least 109 vertebrate species, which representa a significant proportion of total vertebrate species loss. (US, p. 121) Not surprisingly, island species are the most vulnerable to non-native species. A global assessment of the impacts of non-native species found that 75 percent of animal extinction worldwide since 1600 are island species, and evidence suggests that pressures brought to bear upon native biota because of alien species is particularly severe.

In addition, a fuller understanding of the economic costs of alien invasive species is emerging, with most analysis focusing on higher profile examples include the zebra mussel, the kudzu (*Pueraria lobata*), saltcedar and water hyacinth, the purple loosetrile and the European starling. In the United States, documented economic losses from 79 taxa during the 20th century have been conservatively put at US$97 billion. The costs of the zebra mussel alone, which was carried through the ballast tanks of cargo ships and introduced in the Great Lakes in 1988, has already run into billions, while the costs to the power industry over the next decade are estimated to be in the range of US$3 billion. (US, ibid) However, such cost estimates only capture observed effects, while indirect economic costs – in terms of longer term impacts on biodiversity, on human-health, on soil productivity – is much higher.

V. Farm Income and Equity

In examining the impacts of trade liberalization, there are numerous important benefits expected to accrue from trade policy reform. Increased general welfare, and higher GDP per capita, are the benefits most often cited by advocates of free trade. The literature demonstrates that countries that adopt more "open" economies (definitions of openness vary) grow more quickly than countries with closed economies. For example, one study (Sachs and Warner, 1995), in comparing 34 developing countries, found that open economies grow at twice the rate of closed ones.

Other benefits from trade liberalization include a general reduction in the risk of long term volatility, on the premise that world markets – with more players than closed domestic markets –

are inherently more stable than purely domestic ones[60]. At the same time, the opening of markets to international competition makes it extremely difficult for countries to shield themselves from international market volatility. Recent examples of volatility include excess supply, a decline in global food demand, especially for developing countries in which income-food demand correlations are extremely sensitive), currency exchange and other factors.

However, the most important benefit of trade liberalization is the contribution it makes to general welfare gains. Generally, welfare gains come about by an increase in the efficiency with which an economy makes uses of its productive resources, and by changes in a country's terms of trade. Although general welfare gains is now universally accepted, the relationship between overall welfare improvements and equity remains far less clear.

There are numerous reasons why equity is viewed as being an essential factor in the conservation of biological diversity. Perhaps the most important is the very strong relationship between community-based conservation initiatives in sustainable resource use and sharing, and the level of equity that exists within those communities. Put another way, communities and societies that exhibit very high levels in inequity generally also show higher rates of biodiversity loss [true?]. Accordingly, one of the three pillars of the UN Convention on Biological Diversity is the pursuit of equity.

In recent years, as attention has increasingly focused on welfare issues related to economic globalization, there has been growing recognition that while market integration spurs faster rates of economic growth, it also makes it more difficult for governments to implement equity-related policies, including education, health care, pension security, minimum wage levels and environmental and conservation-related policies. Part of this difficulty relates to perceived negative effects of equity-based policies on a country's competitiveness stance in extremely tight global markets. Increased capital mobility, one of the obvious attributes of globalization, makes it more difficult for governments to tax capital, and in response many countries have shifted tax policies to labor.[61] (IMF, 1999) The consequences of increased labor taxation on equity remains an open question.

However, what is clear is that as trade liberalization proceeds, the income gap between rich and poor countries has widened rather than narrowed. Today, according to the WTO, that gap is "huge". Richer countries grow much faster than poorer ones, and income disparities between developed and developing countries on average are widening.[62] From an international trade perspective, the question is whether market integration through trade narrows or widens income gaps. Empirical evidence suggests that export and import relations appear to facilitate income convergence at approximately equal rates[63].

However, this equalization is calculated on an aggregate basis, and says very little either way about the effects of liberalization policies on equity. Clearly, trade affects not only the income opportunities of a labor force, but also the structure of labor markets. Specifically, there is a widespread view that open markets and free trade adversely affects the poor, by way of hurting

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[60] WTO (2000), *Special Study: Trade, Income Disparity and Poverty*, Geneva.

[61] The most visible tool to address equity issues is through income redistribution schemes. That is, since the capacity of governments to undertake income redistribution policies in the face of globalization is seen to be small, it is assumed that addressing equity goals through revenue redistribution is seen as more effective than adjusted tax rates.

[62] WTO (2000), *Special Study: Trade, Income Disparity and Poverty*, Geneva.

[63] *Ibid.*

unskilled workers in industrialized countries. The literature suggests that other factors aside from import competition – namely technological innovation and migration patterns – have had a greater effect on unskilled workers in industrialized countries that structural changes induced by trade policy reform[64]. More research is needed to understand the dynamic relationship between changes in agricultural production within countries, and the effects these changes have on labor. More specifically, to what extent will increased liberalization support income convergence in the farm sector between developing and developed countries?

As noted, the agricultural sector represents a more important source of employment in developing countries, than it does in developed ones. The farm sector also exhibits very high rates of poverty. Farm workers consistently show the highest incidence of poverty, when compared to any other economic sector. (ILO working paper, cite reference). Poverty and low wage levels are found in most developing countries in which agriculture absorbs a large proportion of the total labor force.

In 1996, the world agricultural labor force was approximately 1.14 billion. This figure is likely to be much higher, since in many countries, the significant contribution that women make to agricultural productivity remains unrecorded. The proportion of the world's economically-active population engaged in agriculture was 47 percent in 1990. It is expected to decline to 42 percent by 2000, and to 38 percent in 2010. Wide differences exist between regions in the distribution of agricultural labor: Asia accounts for approximately 80 percent of the world's total agricultural labor force, followed by Africa at 14 percent. China and India together account for 60 percent of the world's agricultural labor force. (ILO, 2000) By contrast, within most OECD countries, the farm labor force represents between 3 and 5 percent.

Based on projections about the probable impacts of trade liberalization in the agricultural sector, developing countries are widely expected to expand farm production, and farm labor. As noted, this is not expected to occur in a linear way, in large part because liberalization of the farm sector is taking place at the same time that liberalization is occurring in non-agricultural sectors. Off-farm liberalization is therefore expected to change the cost ratio of farm production. For example, liberalization in the manufacturing and services sectors will likely lower the costs, in value terms, of capital inputs to agriculture and food processing. Currently, agro-chemical inputs represent up to 35 percent of total production costs for flowers, and up to 20 percent for more for some higher value vegetables, such as snow-peas.[65] As total costs are expected to decline for important capital inputs, it remains unclear to what extent a reduction in input-related production subsidies will be partially offset by a reduction in the absolute cost of the capital inputs.

However, the most important question concern the contribution that trade liberalization will make to farm employment, especially for developing countries, not only on an aggregate basis, but in terms of the structure of labor markets. Developed countries are characterized by higher levels of wage and salaried workers, on average between 70 to 90 percent. By contrast, self-employment in developed countries is at roughly 10-15 percent. In developing countries, the proportion of wage and salaried workers is much smaller, while the proportion of self-employed and unpaid family workers is much higher.

This question of wage and salaried workers as a percentage of the entire work-force is directly relevant to equity and overall development, since a very strong relationship exists between the real development indicators -- expressed as per capita GDP – and the proportion of wage and

[64] Gary Burtless et al (1998), *Globaphopia*, The Brookings Institute, Washington, DC
[65] Lori Ann Thrupp (1995), *Bittersweet Harvests for Global Supermarkets,* World Resources institute, Washington.

salaried workers within an economy (ILO, 2000). Given the scope of informal labor markets in the farm sector in developing countries, it cannot be assumed that expanded production will automatically be translated into development equity.

A. Wage Earnings and Non-Traditional Farm Exports

To illustrate, non-traditional, export-oriented crops from developing countries, including fresh and processed fruits and juices, vegetables, flowers and nuts,[66] suggest wage rates are low, often below existing minimum wages. Jobs tend to be both insecure and highly seasonal, in particular in fruit and vegetable processing. Many developing countries exhibit not only a very higher proportion of temporary workers, but a higher incidence of child labor in non-traditional export crops. Studies have shown that women working in fruit and vegetable processing receive lower wages than their male counterparts, work longer hours, and receive no additional pay for overtime. Health problems for women workers tend to be higher than for men, including recorded incidents of exposure to pesticides in case studies. Evidence also suggests that seasonal workers in non-traditional export crop markets are often unable to form labor unions. (ibid)

When examining equity in its own right, and how it compares to rates of biodiversity loss, a common problem is that no single indicator adequately captures its many dimensions. The most common indicator of equity remains total wage earnings. Other indicators are also relevant, including for instance land ownership. Another way of looking at equity issues related to trade liberalization is the extent to which trade narrows or widen wage differentials between skilled and unskilled, and between salaried and unsalaried wages. Studies show uneven results in this regard, from negligible impacts to as much as 50 percent impacts[67]. According to a recent study, income inequality is highest in Latin America and sub-Saharan Africa. In Latin America, for example, the average "Gini coefficient" is 0.5[68].

[66] Traditional export crops from developing countries typically comprise coffee, tea, bananas, cotton and sugarcane.
[67] However, what the empirical data does show is that the relative wages of unskilled workers in East Asian countries rose in the 1960s and 1970s, but has fallen in the 1980s and 1990s.
[68] The Gini coefficient is the most commonly-used measurement of income equality, with 0=full equality, and 1=total inequality. IMF Working paper, "Equity and Economic Policy, 1999