CBD

UNEP

CONVENTION ON BIOLOGICAL DIVERSITY

Distr.
GENERAL

UNEP/CBD/COP/6/INF/2
4 March 2002

ORIGINAL: ENGLISH

CONFERENCE OF THE PARTIES TO THE
CONVENTION ON BIOLOGICAL DIVERSITY
Sixth meeting
The Hague, 7-19 April 2002
Item 16 of the provisional agenda*

THEMATIC PROGRAMMES OF WORK—PROGRESS REPORTS ON IMPLEMENTATION: AGRICULTURAL BIOLOGICAL DIVERSITY

Assessing the impact of trade liberalization on the conservation and sustainable use of agricultural biological diversity

Note by the Executive Secretary

I. OVERVIEW

1. The present note has been prepared by the Executive Secretary of the Secretariat of the Convention on Biological Diversity, pursuant to decision IV/6, paragraph 10, of the Conference of the Parties, which requests the "Executive Secretary to report to the Conference of the Parties on the impact of trade liberalization on the conservation and sustainable use of agricultural biological diversity in consultation with relevant bodies, such as the World Trade Organization."

2. The relationship between trade liberalization, agriculture and biological diversity is complex and inherently dynamic. 1/ In consequence, different assessment sequences are needed to examine the impacts of trade liberalization on agricultural biodiversity. One option is to first assess the economic impacts of trade liberalization on farm production. Second, the impacts of agricultural production on biological diversity can be examined, drawing on methodological lessons from environmental assessments of agriculture more generally. 2/ The remainder of this introduction elaborates on each of these steps and outlines the structure of the respective sections to follow.

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* UNEP/CBD/COP/6/1 and Corr.1/Rev.1.

1/ C. Ford Runge, "Economic Trade and Environmental Protection," Paper prepared for the conference on Environmental Policy with Economic and Political Integration: The EC and the US, University of Illinois, 1993.

2/ Hence, 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.

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A. Trade liberalization and farm production

3. In light of the complex, case-specific relationship between agricultural production and biological diversity, coupled with the difficulty in forwarding robust data-grounded coefficients, estimating the extent to which trade liberalization affects biodiversity on an aggregate basis must rely largely on stylized observations. Despite the problems of assigning clear causal links between trade liberalization and biological diversity, a useful starting point is to examine the extent of trade restrictions and distortions in the agricultural sector, extrapolate probable impacts of liberalization on changes in relative prices, and then extrapolate further how changes in relative prices alter the allocation of resources within and between markets

4. Section II of the present note will address these effects more extensively. Before doing so, however, section II will review in brief the difficulties in delineating effects of trade policy reform from other factors that affect world markets (sub-section II.A). In this respect, the removal of natural barriers to trade and the general decline in transportation costs need especially to be stressed, because it directly feeds into the problem of alien invasive species and thus constitutes the most important direct impact of export growth on biological diversity. Section II will proceed to review in brief the main trade liberalization efforts within the World Trade Organization (WTO) and their prospective consequences for trade distortions (sub-section II.B) before providing an analysis of the effects of trade liberalization on agricultural markets (sub-section II.C).

B. Biological diversity and the farming sector

5. Farming and the crucial benefits it yields – including food security, domestic employment and export-related economic growth – depends on agro-biodiversity. Agricultural systems are ecosystems, in which processes such as nutrient recycling, maintenance of soil fertility, and the regulation of populations of insect pests by natural enemies, are important factors of the sustainability of both systems. 3/

1. Defining agricultural biological diversity: scope and difficulties

6. Adding to the complexity of assessing biodiversity impacts of agriculture is the broad concept of agricultural biological diversity. In the appendix to its decision V/5, the Conference of the Parties to the Convention on Biological Diversity presents the scope of agricultural biodiversity as being "a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agro-ecosystem: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes, in accordance with annex I of decision III/11 of the Conference of the Parties to the Convention on Biological Diversity." The Conference of the Parties has recognized "the special nature of agricultural biodiversity, its distinctive features, and problems needing distinctive solutions".

7. Seven distinctive features are enumerated highlighting its essential role to satisfy basic human needs for food and livelihood security, the role of farmers and indigenous knowledge and culture in managing agro-biodiversity, the high interdependence between countries for genetic resources for food and agriculture, the importance of intra-specific diversity in crops and domestic animals as well as the complementary role of *ex situ* and *in situ* conservation. It also identifies the dimensions of agricultural

3/ P.J. Edwards *et al* (1999), "The Effects of Alternative Tillage Systems on Biodiversity in Agro-ecosystems," in D. Wood and J.M. Lenne, eds., *Agrobiodiversity: Characterization, Utilization and management,* CABI Publishing Ltd., London.

biodiversity, including: (i) the genetic resources for food and agriculture, including cultivated species, domesticated species and managed wild plants and animals, as well as wild relatives of cultivated and domesticated species; (ii) the components of agricultural biodiversity that provide ecological services, including a diverse range of organisms in agricultural production systems that contribute at various scales; (iii) abiotic factors, which have a determining effect on these aspects of agricultural biodiversity; and (iv) socio-economic and cultural dimensions, as agricultural biodiversity is largely shaped by human activities and management practices, including traditional and local knowledge of agricultural biodiversity, cultural factors and participatory processes.

8. As this concept is very broad, it is difficult to use it for highly aggregated trade-related assessments. Given this difficulty, it is not surprising that environmental assessments of agricultural trade have provided the clearest findings when examining various coefficients between economic or export growth on the one hand, and changes in various pollution-related emissions – such as $N0_x$, $S0_x$, nutrients or particulate matters – on the other. 4/ That is, data correlations fit more easily into quantitative economic or ecological models, provided quantitative-based indicators exist with which to assemble data and measure changes in the trajectory of environmental quality. Unfortunately, to date most indicators of biological diversity tend to be qualitative rather than quantitative, making it very difficult to run models or observations grounded in empirical data. 5/

9. Notwithstanding the difficulties to use the above definition of agro-biodiversity for the purpose of an aggregate analysis in the context of trade liberalization, it is useful to note that agro-diversity includes crops and domesticated livestock, their wild relatives as well as wild flora and fauna ecosystems, as well as numerous interacting species such as pollinators, symbionts, pests, parasites, predators and competitors.6 As the distribution of these components as well as possible impacts on them, are different and uneven among regions, they may need different and mutually supportive policy approaches.

2. Effects of agriculture on biological diversity

10. One of the most useful conceptual frameworks to examine trade effects identifies five distinct environmental effects: (a) allocative efficiency effects; (b) scale of economy; (c) output composition; (d) technology effects, and (e) changes in environmental policies. 7/ The aggregate environmental impacts of trade growth can in theory be measured by the sum of each of these effects.

11. The effects of the farming sector on biological diversity entail both direct and indirect impacts. An important effect of agriculture on biological diversity revolves around issues of land-use change: habitat alteration, degradation or fragmentation linked with an expansion, contraction or shift in the characteristics of arable land. In addition to land use change, the adoption of production intensification methods has

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4/ See for example "Final Analytical Framework to Assess the Environmental Effects of NAFTA," in OECD, Assessing the Environmental Effects of Trade Liberalization Agreements, Paris 2000.

5/ Efforts are underway by a number of organizations, including the OECD, in developing composite indicators for biological diversity, and 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.

6/ .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.

7/ C. Ford Runge, "Economic Trade and Environmental Protection," Paper prepared for the conference on Environmental Policy with Economic and Political Integration: The EC and the US, University of Illinois, 1993.

important impacts on biological diversity. Examples include the reliance on a narrow and homogenous range of plant genetic resources for the bulk of the world's food outputs, or impacts linked to capital inputs, including farm machinery or the use of fertilizers and pesticides. Each of these characteristics has important implications for biological diversity.

12. The purpose of the present note is to examine the extent to which trade liberalization influences agricultural biodiversity by way of altering these factors, individually and on an aggregate basis. This analysis will be presented in section III of the present note, and will be organized along the lines of the two effects mentioned above: the impact on land use and land-use change (sub-section III.A) and the impact of increased production intensity (sub-section III.B). Sub-section III.C will address the impact of the removal of natural barriers to trade, under special consideration of the problem of alien invasive species, and sub-section III.D will give a preliminary overall assessment of the different effects.

II. THE IMPACT OF TRADE LIBERALIZATION ON AGRICULTURAL MARKETS

13. In recent years, work has increased around assessing the environmental impacts of trade liberalization in general, including the environmental effects of trade liberalization in agriculture. Among the lessons of recent work is the difficulty in delineating effects of trade policy reform from other factors that affect world markets. 8/ As in most other sectors, factors that include price changes and price volatility; changes in technologies; demand elasticities; the effects of other economic reforms; or the effects that liberalization in other sectors (for example, on relative capital or labour costs) all have to be considered for an overall assessment. 9/

A. Structural changes in world agricultural markets

14. Even before an examination of the impacts of trade liberalization begins, it is important to recognize the profound restructuring that international agricultural markets have been undergoing. Importantly, these structural changes are quite apart from trade policy reform effects, even while efforts for trade liberalization may further foster such developments. Three examples– changes in product demand, changes in production methods, and changes in transportation-related costs – illustrate the scope and these changes, and are noted because each is likely to exert important impacts on biological diversity.

15. First, important changes in food consumption patterns continue, with evidence suggesting that such changes are closely correlated with growth in GDP per capita. While total food demand remains relatively inelastic, evidence suggests that income growth in developing countries is stimulating increased demand for meat and processed foods. 10/ This demand shift helps explain a demand 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

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8/ Studies by Frankel and Romer have gotten around this, by using a distance-correlated proportion of trade as an instrumental variable, so as to isolate trade effects. That is, trade patterns explained by distance is unlikely to be linked closely with changes in domestic economic policies. They find that strong evidence that countries that trade more also enjoy higher per capita incomes.

9/ Isolating the impacts of trade liberalization in the farm sector is especially tricky, given the extent of market failures, structural and other rigidities that generally define commodity markets, coupled with the impacts of climate and other kinds of production shocks.

10/ UNEP, Sustainability and the Agri-Food Industry, Industry and Environment, Vo. 22, No.2-3, April-September, 1999

levels. 11/ At the other side of the income spectrum, anecdotal evidence suggests that in higher income countries, there is a marginal demand shift to foods that are processed with low-impact production methods. Examples include the very strong growth in organic foods in North America – a recent study suggests organics are growing at 30 per cent per annum (CEC, 2000) – while public concern about foods produced with genetically modified organisms appears to be on the increase in many industrialized countries, led by western Europe.

16. Second, important changes in farm production – although not as dramatic as the Green Revolution – continue. 12/ As global market competition rises, production in many instances has moved to larger-scale, modern or industrial-type agricultural and livestock production. Typically, the concentration in production factors is also associated with high rates of specialization. Specialization in the farm sector often means a reliance on a very narrow range of plant genetic resources for food output, supported by capital inputs to increase output. Three different kinds of capital inputs are used in the farm sector: (a) purchased capital, such as machinery, which largely acts as a substitute for labor inputs; (b) purchased capital such as fertilizers, pesticides and more recently, genetically modified organisms, which serve as substitutes for land; and (c) natural capital not directly linked with land, including livestock. 13/ The impacts of production concentration, specialization and increased reliance on capital inputs on biological diversity can be important. As trade liberalization may create additional incentives for production intensification, some of these impacts are examined more extensively in section III.B.

17. Third, profound changes in agricultural markets result as natural barriers to trade decrease in conjunction with a decline in transportation costs. Examples include a decrease in the cost of marine transportation, and an extension in roads to penetrate into natural areas for resource extraction and the establishment of new production locations. The impacts of improved transportation on biodiversity are numerous. They include the fragmentation of natural habitats (habitat connectivity), but also, and above all, the creation of new pathways for alien invasive species through expanded international transportation corridors. 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. In consequence, even 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 one of the most important causes of biodiversity loss, alien invasive species. For this reason, this issue will be more fully considered in section III.C.

B. Liberalizing international trade in agriculture

1. The WTO process

18. 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 spiralling 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 include tariffs, quotas, income support measures, export

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11/ John Cranfield et al, "Changes in the Structure of Global Food Demand," August 1998, GTAP

12/ Agricultural land intensity – the number of hectares per worker – has decreased in every region of the world from 1980 to 1995 as a result of the growth in world labor force growth in other sectors compared to agriculture. During the same period, the share of rural labor declined in every region. (ibid.)

13/ Arild Angelsen et al (1999), op cit,

subsidies, subsidies on productive inputs, decoupled financial transfers calculated other than by output volume, and tariff rate quotas.

19. 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 General Agreement on Tariffs and Trade (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, the Agreement on Sanitary and Phytosanitary Measures, and the Agreement on Import Licensing Procedures.

20. Three main categories of disciplines are contained in the Agreement on Agriculture: (a) rules to lower border protection, in particular through the tariffication of non-tariff measures coupled with tariff reduction commitments covering almost all tariff lines; (b) rules intended to reduce export subsidies; and (c) rules to limit domestic support measures.

21. With respect to domestic support, the most important type of exemption of the Agreement on Agriculture are the so-called "Green Box" exemptions, which comprise non-trade objectives such as research, disease control, pest control, infrastructure support, and food security objectives, and environmental and conversation objectives. Estimating pre and post-Uruguay Round transfers to the farm sector in support of environmental objectives remains imprecise, although there is consensus that such transfers have increased in developed countries. In 1999, environment-related measures comprise slightly over 10 per cent of all agricultural notifications (WTO/WT/CTE/W/145). Domestic measures include financial transfers for environmentally-related agricultural production, support for soil conservation programs, waste management, water quality management, the preservation of the countryside, forests, and the promotion of sustainable use of "natural" or environmentally-friendly agricultural practices. 14/

22. 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.

23. Given the important 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 controversial 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 Sanitary and Phytosanitary measures (SPS). Given the nine-year discussions that have taken place, and continue, in the WTO Committee on Trade and Environment (and before 1995 in the GATT), the OECD, UNCTAD, the World Bank and elsewhere, it is not the intention of this note to do anything other than point to the continued discussion of this relationship.

14/ Examples include notification by Canada (WTO/G/AG/N/CAN/29), which covers domestic support in support of environmentally-sustainable water irrigation projects; by the Czech Republic (WTO/G/AG/N/CZE/23) which includes support for wetlands, the spread of wild animals, support for eco-agriculture, and the minimization of chemical inputs into agriculture; and by the EU (WTO/G/AG/N/EEC/12), which includes measures for the preservation of the country-side, and the control of soil erosion.

24. Despite the introduction of liberalization rules, profound trade distortions persist in the agricultural sector. Part of the "built-in negotiating agenda" of the Uruguay Round has been to continue the process of trade policy reform in the farm sector, and in March 2000, Parties to the WTO entered Phase One of the process towards re-negotiating the Agreement on Agriculture. The Ministerial Declaration adopted at the Fourth WTO Ministerial Conference in Doha, Qatar, on 15 November 2001 gives further momentum to this process, as it presents a comprehensive agricultural negotiation mandate, including "reductions of, with a view to phasing out, all form of export subsidies." Other major features of the agricultural mandate are substantial improvements in market access and substantial reductions in trade-distorting domestic support. 15/ The declaration confirms that non-trade concerns (which include the environment) will be taken into account in the negotiations as provided for in the Agreement on Agriculture.

2. Impacts of the Commitments of the Agreement on Agriculture

25. Estimating the effects thus far of the WTO on the farm sector remains problematic, both for what is contained in the accord itself, what is not contained in the accord and the subject of future work, and factors – like non-market volatility and implementation related issues. For example, while tariff reduction is a welcome step towards improved market access, actual levels of protection have in some cases increased. Part of this increase can be attributed to inclusion of non-tariff barriers through the tariffication process. However, at least part of this increase stems from the high degree of flexibility available to countries in setting bound Most Favored Nation (MFN) rates within aggregate average tariff reduction schedules, so that tariff rates for many sensitive products have actually increased since the Uruguay Round. Of even greater concern are increases in AMS support measures in developed countries.

26. Given these and other factors, quantifying the effects thus far of the AoA remains imprecise. For some areas, including counting the number of tariff quotas or notifications of export subsidy schedules, progress can be measured. The WTO Annual Report (2000) notes that 37 Member countries (including the EU counted as one Member) have bound a total of 1,367 tariff quotas into their agricultural schedules. Since the introduction of the URAA, eight WTO Members have applied for safeguards. 16/ Nevertheless, some general observations can be made regarding the URAA, given the completion of the initial 1994-1999 implementation period (For a comprehensive account of WTO obligations, please refer to the WTO.)

Export subsidies

27. It is difficult to estimate the extent to which export subsidies have fallen in the implementation of the Agreement on Agriculture over the period 1994-1999, given the nature of export subsidy notifications. It has been noted that over 90 per cent of the total WTO-permitted total outlay of export subsidies is accessible to developed countries, raising concerns about initial flexibility allowed countries is setting export subsidy caps. Rules regarding export subsidy reductions apply to 25 WTO Member countries. A total of 428 export reduction commitments notified by the 25 members. Two of those commitments apply to all agricultural products, five apply to incorporated products, while the remaining 421 export subsidy reduction commitments are product specific, calculated both in terms of budget outlays and as volume commitments.

28. Different estimates exist regarding the total amount of agricultural subsidies, their application and effect. Part of the complexity in making absolute statements about the economic effects of subsidies is that they continue to undergo important changes. For example, within the European Union, Common

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15/ Ministerial Declaration, WTO Ministerial Conference, Fourth Session, Doha, 9-14 November 2001, para. 13.

16/ WTO, *Annual Report*, Geneva, 2000

Agricultural Policy subsidies continue from a per centage of total production, to flat-rate payments calculated per hectare of land. A complex series of payments take place in several developed countries for land set-aside or idling objectives, and such "decoupling" schemes have the potential to be beneficial to the environment.

Market access

29. According to WTO, the probability that exports from least developed countries will encounter non-tariff measures in developed countries is 6.2 per cent. This compares with a probability rate of 16.5 per cent of non-tariff barriers applied in developing countries on imports from least developed countries (LDC).

30. Quantitative restrictions may continue to affect market access of exports. In addition, a number of trade-related measures – including non-automatic import licensing, labelling requirements, state trading, administrative restrictions, standards and other measures related to the Agreements on Technical Barriers to Trade and on Sanitary and Phytosanitary Measures – may affect market access for a number of agricultural products. WTO members are increasingly recognizing the importance of sanitary and phytosanitary measures as a potential hidden trade barrier, especially given the obligations under the Agreement on Agriculture enumerated above.

Domestic measures

31. The OECD reports that since 1998, trends towards a gradual lowering of support to producers has been reversed, with levels bouncing back to those of a decade before. In 1999, the overall cost of agricultural policies in OECD countries was US$361 billion, or US$327 per person within the OECD countries. The main reason for the reversal of this trend is low commodity prices, which have continued to depress farmer incomes. The OECD notes that in the last two years – 1998-1999 – "most of the reduction in support of the previous decade was lost." 17/

C. Liberalizing international trade in agriculture: the impact on agricultural markets

1. General analysis

32. Even while trade policy reform is very far from completion, some tentative observations can nevertheless be made on the effects of trade liberalization in the farming sector.

33. Subsidies and other measures have led to an often chronic overcapacity and over-supply of domestic agricultural markets, which in turn has led to creating a whole series of increasingly complex 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 non-competitive producers to leave competitive markets, resulting in a contraction in some producing countries. At the same time, producers which able to compete on international markets will expand production. Put another way, trade reform both creates and destroys markets.

34. 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

17/ OECD Policy Brief, *Agricultural Policy Reform: Developments and Prospects*, OECD 2000

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 are ambiguous. 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. 18/

35. 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. Modelling assumptions based on the Global Trade Analysis Project (GTAP) 19/ predict the Uruguay Round will result in a 40 per cent reduction in agricultural tariffs, export and production subsidies. 20/ 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 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.

36. The 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. Hence, 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.

37. 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 the structural changes noted above and other factors, including macro-economic developments noted below (sub-section II.C.2). For example, the highest rate of output growth in the farm sector in 1990-1997 has occurred in South Asia and Latin America and the Caribean – with a rate of growth of 2.7 per cent per annum, followed by sub-Saharan Africa at 2.5 and the Middle East and North Africa at 1.7 per cent per annum. In contrast, production in Eastern Europe and Central Asia was contracting at a rate of 6.3 per cent per annum. 21/ And second, the relationship between production expansion and contraction is asymmetric. For example, a 4 per cent contraction in total grain or meat

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18/ Bernard Hoekman and Kym Anderson, "Developing Country Agriculture and the New Trade Agenda," presented to the American Economic Association Annual Meeting, January 1999.

19/ The Global Trade Analysis Project (GTAP) has become a kind of standard agricultural model to assess global changes stemming from 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.

See Thomas S. Hertel, ed. (1997), Global Trade Analysis, Cambridge University Press, New York. To access recent papers or research, see www.agcon.purdue.edu/gtap/

20/ Hertel et al, (2000).

21/ ILO, *Sustainable Agriculture in a Globalized Economy.* Geneva 2000.

production in industrialized countries is rarely followed by a corresponding increase in grain or meat production in developing countries.

38. Despite this asymmetric relationship, changes in the location of agricultural production between regions in general, and between developed and developing countries in particular, as well as corresponding changes in production methods, appear to be a important impact that the trade liberalization will have on biological diversity. 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 very important underlying causes of biodiversity loss.

39. 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. Given these constraints, most analysis of the aggregate impacts of trade liberalization in the farm sector on the environment continues to be based on broad inferences. 22/

1. Recent agricultural market performance

40. The problem with broad inferences about the assumed impacts of trade policy reform is that they often run counter to real world evidence. For example, trade theory suggests that world food prices ought to increase, as liberalization occurs. 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 per cent.

41. As explained in sub-section II.C.1, trade theory also suggests that price distortions – notably subsidies and domestic support schemes – ought 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. 23/

42. 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. Other non-farm factors have contributed to what FAO terms the “continued, pronounced and widespread decline” in agricultural prices. These include the impacts of the financial crises of Asia, Latin America and the Russian Federation, including wide fluctuations in currency exchange rates and devaluations, and unusual supply fluctuations.

22/ David Ervin, “Agriculture, Trade and the Environment: Anticipating the Policy Challenges,” OECD, 1997

23/ OECD Policy Brief, *Agricultural Policy Reform: Developments and Prospects*, Paris, 2000.

Effects on developing countries

43. The effects of collapsing commodity markets and increased subsidy support on developing countries are disproportionately high, and largely severe, compared to their effects on developed countries. A higher proportion of GDP in developing countries is derived from farm exports (compared to developed countries) and a significantly higher proportion of total labor in many developing countries is in the agricultural sector. The share of developing countries in world agricultural exports has marginally increased from 40 per cent in 1990, to 42.5 per cent in 1998. 24/ Despite increases across the board in food exports from most developing countries, in 1999, export earnings fell at a higher rate than the global average, by 15 per cent in developing countries compared to 13 per cent as a world average. The total decline in the value of food export earnings for developing countries in 1999 was US$68 billion. 25/

44. Depending of the strength of the economic income effect, economically rational responses of farmers to depressed prices are either to increase total outputs to reach comparable export earnings, or, to reduce farm sector activities and enter other economic sectors, including for instance the manufacturing or services sector. However, given the scarcity of alternative economic options outside of agriculture that exist in many developing countries, farmers are more likely to expand production in search of earnings in these countries: Studies have shown that this expansion can sometimes occur in marginal or fragile areas, which in turn increases pressures on habitats and accelerates species loss. Conversely, the predicted increase in farm output prices due to trade liberalization measures may then lower incentives to expand production and may thus contribute to a decreased pressure on biological diversity in these areas.

3. Farm subsidies and the environment

45. As noted in section II.C.1, the effects of trade liberalization on agricultural biodiversity are primarily transmitted indirectly through changes in relative prices. In recent years, the predominate focus of trade-environment analysis has zeroed in on the question of farm subsidies, including (i) assessing the environmental impacts of agricultural subsidies and financial transfers, and (ii) estimating how trade disciplines will reduce and reorient such transfers in a way that reduces environmental damages, and increases conservation and effective environmental management policies. Although subsidies are clearly a significant cause of price distortions and wedges in global agricultural markets, trade liberalization is expected to exert other impacts on the sector.

46. Analysis generally suggests that a reduction in subsidies coupled to production 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.

47. 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 the North-American Free Trade Agreement (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

24/ WTO, G/AG/NG/S/S, May 2000

25/ FAO, Commodity Market Review: 1999-2000, Rome 2000. A preliminary estimate of the total value of global agricultural exports in 1999 was US$146 billion.

competitive. 26/ The environmental impacts of larger scale meat production are significant, and are described below. Evidence also suggests that with a reduction in subsidies coupled to production, farmers may move production towards higher-value outputs like horticulture. These higher value outputs generally require large volumes of agro-chemical inputs.

48. 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 Conference of Parties to the Convention on Biological Diversity may wish to consider providing advice to the WTO on best practices in conservation and agro-environmental measures.

49. Another difficulty in making clear pronouncements about the impacts of subsidies reduction is the difficulty in weighing trade-offs between 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. 27/ 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.

III. CHANGES IN THE FARMING SYSTEM AND THE IMPACT ON BIOLOGICAL DIVERSITY

50. Different types of issues arise when looking at the relationship between the changes in agricultural production stemming from trade liberalization and biological diversity.

(a) First, as noted before, trade liberalization is expected to influence a change in 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 in developing countries. The most significant biodiversity-related impacts resulting from changes in the location of farm production centre around the question of land use change. This issue is addressed in the following sub-section (III.A);

(b) Second, 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

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26/ 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.

27/ 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.

applicable in all sectors, so that efficiency gains from scale economies also apply equally to the farm sector as they do to the manufacturing sector. 28/ This issue is addressed in sub-section III.B;

(c) Third, even while not only caused by trade policy reforms, the decline of transportation costs and the export growth it spurred has important direct effects on biological diversity, the most important being the increased threat of invasive alien species. This issue is analysed in sub-section III.C;

(d) Sub-section III.D gives a very preliminary overall assessment of the different effects on agricultural biological diversity

A. Land-use and land-use change

51. As noted before, different estimates have been forwarded regarding the extent and likely pattern of production shifts associated with trade liberalization. One study (1994) estimates an overall contraction of 5 to 6 per cent in total grain and meat production in developed countries, and a 3-8 per cent expansion of meat production in developing countries. 29/ 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. Furthermore, a differentiation is necessary between extensive, biodiversity-rich farming areas and intensive farming areas. The intensification of agricultural production is addressed below. In regard to land-use change, two questions 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?

1. Expansion in farm production and land-use change

52. 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.

53. 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) A shift in land use, within the same product category, but using different agricultural production methods;

(b) A shift in crop use, for example from low value to high value crops, within the same land area, although using different production methods;

28/ In this connection, it has also been argued 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.

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

(c) 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.

54. Turner *et al* have identified three ways in which land use change affects biological diversity.

(a) First, land use changes 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.

(b) Second, the spatial pattern of habitats is 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 biodiversity are direct, often profound and numerous.

(c) Third, land use change 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.

55. 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. There is scope for progress in this regard if good monitoring systems are put in place for some key indicators, notably the quantity and quality of selected habitats. 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*. 30/ That is, the accumulation of small changes in land cover linked to land use poses the greatest challenge in implementing biodiversity conservation programs.

56. Land use is altered by many factors, including the expansion of farm lands, raising of livestock, forest harvesting, the draining of wetlands for agriculture, 31/ the use of irrigation for dry croplands, land conversion for urban areas as well as the abandonment of biodiversity-rich farmland habitats. 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.

57. 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.

2. Habitat fragmentation

58. While the absolute destruction of a habitat will clearly suggest the elimination of species that rely on that habitat, habitat fragmentation also exerts numerous and negative impacts on biological diversity.

30/ Ricker, 1963; USGS, p. 55.

31/ Between 1780s and 1980s, approximately 53 per cent 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.

For example, fragmentation can lead to the loss of a species in single habitat patches as well as the loss from the regional landscape. Fragmentation is a serious problem for both uncultivated habitats and biodiversity-rich (often semi-natural) farmland habitats.

59. The fragmentation – or loss of connectivity – of a habitat depends on its abundance and its spatial arrangement. These impacts have been well documented. 32/ 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.

60. 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.

3. Contraction in farm production and land abandonment

61. Biodiversity-related impacts associated with a contraction in productive lands are often assumed to be positive over time, assuming effective environmental and conservation policies are in place to manage idling or abandoned lands. However, as European experiences suggest, this statement has to be qualified. Indeed, farming systems may actually be important for biodiversity. In consequence, in some century-old European farming landscapes, especially in the remaining extensive farming regions, abandonment is a serious problem for biodiversity conservation. Both intensification in favored regions and abandonment in less favored regions may thus imply negative impacts on biodiversity.

62. Furthermore, even under more favorable circumstances, no recovery can occur for species that have become extinct because of habitat loss linked with the expansion in agricultural production, and recovery is often not expected to return abandoned lands to their natural state prior to the conversion into arable lands within a reasonable timeframe. However, under professional conservation management, restoration may be more likely.

63. 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. 33/ In Europe, many species of plants, invertebrates and birds today depend on certain types of farmland and further losses of those types of farmland habitat would threaten the status of numerous species.

32/ Saunders, 1991, cited in Monica Turner, "Land Use," in United States Geological Survey (1998), *Status and Trends of the Nation's Biological Resources*, Washington.

33/ Monica G. Turner et al, "Land Use," in United States Geological Survey (1998), *Status and Trends of the Nation's Biological Resources*, Washington.

64. 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 (see sub-section III.C below). 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 very difficult.

B. Production intensification

1. Characteristics of modern farm production

65. 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 involve 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.

66. 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. 34/

67. Production intensification 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. However, depending on further developments in regard to the demand shift to foods that are processed with low-impact production methods (see sub-section II.A above), it may not necessarily be true that trade liberalization *discourages* less intensive farm production methods such as agro-forestry, organic farming or integrated pest management.

2. Genetic resources for food and agriculture

68. 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, accumulating a substantive capital of traditional knowledge.

34/ World Resources Institute, *World Resources 2000-2001*, Washington, 2000.

69. 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 – provides an estimated 95 per cent 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 per cent. 35/

70. In this regard, the important role of intra-specific diversity is to be underlined, in particular in providing resilience, reducing vulnerability, and enhancing adaptability of production systems to changing environments and needs. 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 high-yield plant varieties for production intensification is the higher risk 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.

71. Potential indirect impacts of trade liberalization on both the supply of, and demand for genetic diversity in crops and livestock are diverse. For instance, the growth of intellectual property rights and the TRIPs agreement, agricultural input industry consolidation and shifts from public to private sector research and development in seed and breed production may be considered major issues determining availability of genetic diversity in crops and livestock on the supply side. Furthermore, commercial market development can result in incentives to narrow the diversity of varieties and breeds grown due to the packing, shipping and marketing standards they impose, but may also have positive impacts through the creation of niche markets.

3. Agro-chemical use and biodiversity effects

72. Among the characteristics of industrialized or homogeneous factors of agricultural production is an increased reliance on fertilizer and pesticide inputs. Both fertilizers and pesticides have a great impact on biodiversity. While pesticides cause direct mortality of organisms, though in different degrees according to their nature, fertilizers, even at lower levels, lead to sharp reductions of wildlife (e.g. grassland species) on farmland as well as degradation of off-farm habitats.

Fertilizer

73. 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. 36/ 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 per cent of world fertilizer consumption occurred in developed countries. By 1998-1999, fertilizer consumption in developing countries amounted to 61 per cent. 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 have been described by the fertilizer industry itself as "severe." (ibid)

74. 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

35/ FAO, State of the World's Plant Genetic Resources, 1998.

36/ International Fertilizer Industry Association, Statistics, 7 June, 2000.

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 of increased nutrient and other loadings into rivers, streams, lakes and coastal marine areas, including coral reefs 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.

Pesticides

75. 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 45 billion pounds of pesticides are applied yearly, with rates of use having increased sharply in the last twenty years.

76. 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 gaps remain about the combined, incremental and longer-term impacts of pesticide on biodiversity.

77. 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 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. Pesticides are also giving rise not only to pesticide-resistant pests, but also to pathogens and weeds, as well as leading to a decline in populations of natural enemies. Finally, pesticides have also been shown to affect the decomposer system and soil conditions and nutrient turnover.

78. In general, wildlife is exposed to pesticides in two ways. First, animals are directly exposed to a toxic pesticide during spraying, and ingest the chemical directly by 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. Second, 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 (e.g., insects) in areas that have been sprayed with insecticide. 37/ One study has found that bird populations in sun-grown, technified coffee plantations were as much as 90 per cent lower than in canopy-grown, agro-forestry coffee plantations. 38/ Another study has found that 10 per cent of birds exposed to the roughly 900 different types of pesticides applied in the United States – approximately 60 million birds – die. In the sixties a dramatic decline of raptors (birds of pry)

37/ William Palmer et al, "Wildlife and Pesticides: Corn," North Carolina Extension Service.

38/ Smithsonian Migratory Bird Center, cited in Commission for Environmental Cooperation, 1999.

took place in Europe, while a very good recovery took place after the prohibition of persistent organic pesticides.

79. 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 per cent reduction in subsidies results in a 17 per cent reduction in pesticide use and a 14 per cent decrease in fertilizer use. The same study also finds that the complete elimination of subsidies would result in a 35 per cent reduction in total chemical use per acre, and a 29 per cent reduction in fertilizer use per acre. 39/

80. 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 per cent of total production costs for flowers, and up to 20 per cent for more for some higher value vegetables, such as snow-peas. 40/ 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.

C. Trade and alien invasive species

81. 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.

82. Although most of the impacts linking export growth to biodiversity are secondary or indirect – that is through indirect effects of shifts in relative prices –the most important exception to this observation is alien invasive species. 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.

83. "Alien species" refers to a species occurring outside its normal distribution; and "alien invasive species" refers to those alien species which threaten ecosystems, habitats or species. Alien invasive species are a danger not only to wild ecosystems but also damaging agricultural production and agroecosystems. The effect of invasive non-native species on biodiversity is the outright and often dramatic loss of native species (USGS, p. 121). This loss takes place in different ways, and can include

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39/ Jonathan Tolman, "Federal Agricultural Policy: A Harvest of Environmental Abuse," in Competitive Enterprise Institute, 1995.

40/ Lori Ann Thrupp (1995), *Bittersweet Harvests for Global Supermarkets,* World Resources Institute, Washington.

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. Also, bio-invasive species commonly 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).

84. 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 (ibid). 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 (ibid). Estimates also suggest that between 5-10 per cent of introduced species become established, and between 2-3 per cent are able to expand their ranges.

85. 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*), salt cedar 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. Furthermore, investment in quarantine and eradication structures may also be substantive.

D. Balancing trade-offs

86. It is controversial how to compare the immediate effects of concentrated, high-impact farm production on biodiversity – which uses less land for a given total amount of food output – with lower-impact farm production spread across a wider land area. 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. 41/ 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 pressures on natural habitats, including for example tropical forests.

87. 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. However, the concentration of biodiversity in nature reserves is not an automatic process. Furthermore, extensive farming systems in different parts of the world support ecosystems important to biodiversity. In

41/ John Krebs et al, "The Second Silent Spring," in Nature, Vol. 400, 12 August, 1999.

consequence, a co-existence of both extensive (with higher biodiversity) and intensive farming systems (with a reduced need of acreage) will often be needed in practice.

88. While this debate is to be answered with empirical evidence, case studies have suggested that – in cases involving tropical agriculture – the adoption of new, modern agricultural technologies in combination with the expansion of new market outlets for traditional crops like coffee, bananas, palm oil, rubber and sugar cane have led to widespread deforestation. For example, the adoption of concentrated technical agricultural production stimulated deforestation, by making the conversion of forests into arable lands more profitable. 42/ At the same time, the relationship between high-yield agricultural outputs and its effects on forestry conservation and rates of deforestation remains incomplete and ambiguous.

IV. SUMMARY OF PRELIMINARY FINDINGS

89. Given that the relationship between international agricultural trade, trade liberalization and biological diversity is highly complex and dynamic, it is difficult, for any analysis, to forward robust data-grounded coefficients. Hence, an estimation of the extent to which trade liberalization affects biodiversity on an aggregate basis must rely largely on stylized observations.

Procedure

90. The present note uses a specific assessment sequence to examine the impacts of trade liberalization on agricultural biodiversity. As a starting point, it examines the extent of trade restrictions and distortions in the agricultural sector, to extrapolate probable impacts of liberalization on changes in relative prices, and then to extrapolate further how changes in relative prices alter the allocation of resources within and between markets. In a next step, the impacts of agricultural production on biological diversity are examined. These steps allow to deduce the largely indirect impacts of trade liberalization on biodiversity.

International market restructuring

91. Apart from trade policy reform effects, international agricultural markets have been undergoing a profound restructuring. The corresponding changes in **product demand**, in **production methods** and in **transportation-related costs** are important to note because each is likely to exert important impacts on biological diversity.

Trade policy reform measures

92. The Agreement on Agriculture includes three main categories of disciplines: rules to lower border protection, in particular through the **tariffication** of non-tariff measures and through **tariff reduction commitments**, rules intended to **reduce export subsidies** and **rules to limit domestic support** measures.

Price effects and location shifts

93. The frequency and actual levels of price-depressing interventions like subsidies and domestic support measures are expected to decline, as well as price-increasing tariffs and other measures. The counter-balancing price effects which tend to result from the simultaneous reduction in price-suppressing

42/ See Barraclough and Ghimire, 1995, cited in Arlid Angelsen et al (1999), ibid.

subsidies – which when lowered reduces overall volumes – and price-increasing tariffs – which increases import volumes – have been described as "ambiguous." However, many analysts expect that trade liberalization will narrow the price wedge between domestic and world food prices, leading on average to **an increase in farm output prices**. Furthermore, several studies have concluded that trade liberalization will contribute to a **contraction** in total agricultural production in developed countries, with different impact on biodiversity in intensive and extensive farming systems, and to an **expansion in production** in developing countries.

Land use and land-use change

94. Important effects of agriculture on biological diversity revolve around issues of land-use change: habitat loss, alteration, degradation or fragmentation linked with an expansion, contraction or shift in the characteristics of arable land as well as the decline of biodiversity due to increasing intensification. Changes in the location of agricultural production between regions in general, and between developed and developing countries in particular, prompted by trade liberalization, appear to be a very important impact that the trade agenda will have on biological diversity.

95. The extent of that change in land use depends on the type of crop and crop production method. Examples of land use change associated with the farm sector have included the clearing of primary forests for arable lands, the conversion of natural prairies and grasslands for crop growing or livestock grazing and the draining of wetlands either for irrigation or land conversion purposes.

96. While the absolute destruction of a habitat will clearly imply the elimination of species that rely on that habitat, **habitat fragmentation** also exerts numerous and negative impacts on biological diversity. Fragmentation – or loss of connectivity of a habitat – can lead to the loss of a species in single habitat patches as well as the loss from the regional landscape. The fragmentation of a habitat depends on its abundance and its spatial arrangement.

97. Even while biodiversity-related impacts associated with a **contraction in productive lands** are often assumed to be positive over time, if effective environmental and conservation policies are in place, this thesis has to be somewhat qualified in the light of European experiences. These experiences point to the value of some extensive farming systems for biodiversity, which implies that their disappearance has negative consequences for biodiversity. Also, no recovery can occur for species that have become extinct because of habitat loss linked with the expansion in agricultural production, and recovery is often not expected to return abandoned lands to their natural or semi-natural state prior to the conversion into arable lands.

98. 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 is not necessarily proportional.

99. Clearly, in certain case, **other policies** besides trade liberalization affect the environmental impacts of land conversion at least as much, and more than trade policy reform. These policies 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 **very difficult**.

Intensification of production

100. In addition to land use change, the adoption of **production intensification** methods has important impacts on biological diversity. Examples include the reliance on a narrow and homogenous range of plant genetic resources for the bulk of the world's food outputs, or impacts linked to capital inputs, including the use of fertilizers and pesticides or farm machinery . Given the wide variation in farm methods and crop/livestock outputs, it is difficult to examine precise impacts on biodiversity on an aggregate level.

101. 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 the higher risks of genetic vulnerability.

102. 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.

103. Although most of the impacts linking export growth to biodiversity are secondary or indirect – that is through indirect effects of shifts in relative prices –the most important exception to this observation is **alien invasive species**. 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. The effect of invasive non-native species on biodiversity is the outright and often dramatic loss of native species. 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.

104. Production intensification 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. Concentration may also include the abandonment of extensive farming practices often important to biodiversity. Furthermore, intensive farming practices have an impact on non farmed (or uncultivated) habitats by means of ground and surface water pollution and air pollution (ammonia). This all makes the immediate impacts of modern farming on biodiversity negative.

Comparing effects

105. How to compare the immediate effects of concentrated, high-impact farm production on biodiversity – which uses less land for a given total amount of food output – with lower-impact farm production spread across a wider land area is still under considerable debate. Studies suggest **ambiguous outcomes** of less intensive, more environmentally friendly agricultural production spread throughout the country-side, compared with highly concentrated and intensive production in agricultural bread-basket regions with separate, large-scale nature reserves, national parks and buffer areas. In practice, a co-existence of relatively intensive farming (but within environmental standards), and extensive, biodiversity-sensitive farming in other areas, is likely to be an effective and viable option for the conservation of biodiversity.

The role of environmental policies

106. Impacts of trade policy reforms on biodiversity also appear to be contingent on their **specific design** and their **connection to other policy areas**. While trade liberalization might often not directly cause environmental impacts, it may often magnify or trigger them. A policy change which links domestic production to global markets and demand may create a situation in which weak or incomplete environmental policies become more evident by virtue of the fact that increased production to meet that larger demand has large scale effects on the environment, and magnifies environmental damage due to the failure to fully incorporate environmental costs into decision making.

107. In regard to the design of trade policy reforms, the 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. However, the impact of general subsidy reductions appear to be mixed, and not only because the withdrawal of subsidies may also spur farmers towards higher levels of economic and production efficiencies, which, in turn, generally require larger volumes of agro-chemical inputs. The important point is that specific financial support measures in the farm sector decouple farm payments from agricultural production and tie them to the attainment of environmental objectives. Examples include payments for greenbelt areas, landscaping objectives, land set-aside initiatives and agri-environmental programmes.

108. The relationship between trade rules – intended to secure price-neutral trade measures – and domestic conservation and sustainable use policies needs special scrutiny. 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 schemes or other measures aimed at habitat and species protection, then COP may wish to consider providing advice to the WTO on best practices in conservation and agro-environmental measures.

109. The study made clear that is it very difficult to derive clear impacts and related policy options on an aggregate level. The lack of sufficient and reliable data was identified as a major underlying cause for these difficulties, which led to the necessity to rely to a large extent on stylized observations. In future research, there is a need to place related observations in a more specific ecological, economic and social context, also to enable the definition of appropriate and specific policy responses. In this regard, a recent promising project of the UNEP's Environment and Trade Branch has to be mentioned, which endeavors to evaluate the impact of trade measures on the agricultural sector by country- and crop-specific case studies. 43/

43/ Additional information can been found under http://www.unep.ch/etu/draft/agri.

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ACRONYMS AND ABBREVIATIONS

AMS	aggregate measure of support
AoA	Agreement on Agriculture
CBD	Convention on Biological Diversity
COP	Conference of the Parties
FAO	Food and Agriculture Organization of United Nations
FOA	Futures and Options Association
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GSP	Generalized System of Preferences
GTAP	Global Trade Analysis Project
IPM	integrated pest management
LDCs	least developed countries
MFN	most favoured nation
NAFTA	North American Free Trade Agreement
NTB	non-tariff barrier
OECD	Organisation for Economic Co-operation and Development
SPS	sanitary and phytosanitary measures
TBT	technical barriers to trade
UNCTAD	United Nations Conference on Trade and Development
URAA	Uruguay Round Agreement on Agriculture
USGS	United State Geological Survey
WTO	World Trade Organization
