Interregional Ecology – Resource Flows and Sustainability in a Globalizing World

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Abstract

In a globalizing world, trade has become essential to supporting the needs and wants of billions of people. Virtually everyone now consumes resource commodities and manufactured products traded all over the world; the ecological footprints of nations are now scattered across the globe. The spatial separation of material production (resource exploitation) from consumption eliminates negative feedbacks from supporting eco-systems. Most consumers remain unaware of the impacts that their trade dependence imposes on distant ecosystems (out of sight out of mind).

I take the first steps in developing a conceptual and practical framework for an ‘interregional ecology’ approach to exploring and analyzing sustainability in an increasingly interconnected world. Such an approach accounts for some of the ‘externalities’ of globalization and international trade. It underscores the increasing dependence and impact of almost any country on resources originating from others and recognizes that the sustainability of any specified region may be increasingly linked to the ecological sustainability of distant supporting regions.

I empirically describe and quantify some of the interregional material linkages between selected countries. I document the flows of renewable resources into the U.S. and quantify the U.S. external material footprint (EF) on specific countries. I then document the physical inputs involved in production of most agricultural export products from Costa Rica and Canada. Finally, I focus on major export products such as bananas, coffee and beef in Costa Rica and agricultural activities in the Canadian Prairies and document some of the ecological consequences (loss of habitat, soil degradation, water contamination and biodiversity loss) of that production. My research findings show increasing U.S. imports, increasing reliance on external sources and growing external ecological footprints. They also show how production activities mostly for overseas consumption led to changes in ecological structure and function in the studied export countries.

This dissertation adds a missing trans-national dimension to the sustainability debate effectively integrating the policy and planning domain for sustainability in one region with that in others. While my research focuses mainly on documenting the nature and magnitude of interregional connections I also consider some of the implications of the interregional approach for sustainability planning.

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List of Acronyms

EFA –	Ecological Footprint Analysis
EKC –	Environmental Kuznets Curve
GDP -	Gross Domestic Products
Ha -	Hectares
IMF -	International Monetary Fund
Km$_2$ -	Square kilometer
LCA –	Life Cycle Assessment
LULC -	Land use and land cover change
MEA –	Millennium Ecosystem Assessment
MFA -	Material Flow Analysis
Mt –	Metric tonnes
Mt/yr –	Metric tonnes per year
M$_3$ –	Cubic Meter
No -	Number
PIOT –	Physical Input Output Tables
TNC –	Trans National Corporations
WTO –	World Trade Organization

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Chapter I - Introduction

In a globalizing world, trade has become essential to supporting the needs and wants of billions of people. Virtually everyone now consumes resource commodities and manufactured products traded all over the world; the ecological footprints of nations are now scattered across the globe. The growth and manufacture of products creates many impacts on ecosystems particularly at the point of production. Most consumers, however, remain unaware and do not receive any negative feedback, of the impacts that their trade dependence imposes on distant ecosystems.

The overall context of my dissertation is ecological sustainability. I develop an 'interregional human ecology' theoretical approach to explore and analyze sustainability in a globalizing world. This approach underscores the increasing dependence and impact of almost any country on resources originating from others and recognizes that the sustainability of any specified region may be increasingly linked to the ecological sustainability of distant supporting regions. I describe and quantify several interregional connections and their impacts on the ecological integrity of exporting countries.

1.1 Problem statement: The Sustainability Conundrum

"Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth. The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services"(Millennium Ecosystem Assessment, 2005: 1) .

In the last several decades human activities have dramatically increased the pressure on supporting ecosystems all over the world. The above statement joins many others in emphasizing the deteriorating state of human - ecosphere connections. The evidence increasingly emphasizes the dangerous path we are on (e.g. Meadows et al. 1972; 2004; WCED 1987; EUROSTAT 2001a; UN 2001; MEA 2003; 2005).

Approximately 40% of the earth's terrestrial surface are now cropland and pastureland, most of which was converted in the last 30 years (Foley et al. 2005). Despite an annual increase in the area of temperate forest by almost 3 million hectares between 1990 and 2000, the world's forest area overall has been shrinking. From 1980 to 2000 deforestation in the tropics occurred at an average rate of more than 12 million hectares per year (MEA 2005; FAO 2005).

Approximately 20% of the world's coral reefs have been lost and an additional 20% degraded in the last several decades (MEA 2005). Approximately 35% of all mangrove area has been lost (MEA 2005). Another consequence of global human activity is that the number of species on the planet is declining. Between 10 and 30% of mammal, bird, and amphibian species are under threat of extinction (MEA 2005). This decline is due largely to human population growth and increasing levels of human material and energy consumption. Fulfillment of human demands over time has altered ecosystems such that some species have lost the habitats to which they are adapted; other threatened species have been the targets of human exploitation.

Since 1960, the world population has more than doubled to 6.5 billion people (UNPP 2007). The global economy has increased more than sixfold (MEA 2005). Within that period food production, for example, has increased by roughly two-and-a half times, and water use has doubled (MEA 2005). Timber production increased by more than half while wood harvested for pulp and paper production has tripled (MEA 2005). Cotton production increased 1.5 times, iron by 1.2 and aluminum by 1.9 (Meadows et al. 2004). From 1973 to 2004 global energy consumption increased by 80% (IEA 2006). According to the World Trade Organization (2005:31) on average from 1960 to 2004 the volume of world trade has annually increased by 6.1%. The trade value has increased from 163 billion U.S. $ in 1963 to 9,250 billion U.S. $ in 2004 (WTO 2006:32).

Our unique stage in human history has been examined by many authors (e.g., Meadows et al. 1972; 2004; Catton 1980; MacNeill et al. 1991; Norgaard 1994; Rees 1995; Adams 2001; Dale 2001; Speth 2004; MEA 2005; Brown 2006), all of whom emphasize the need for reassessment of our way of life and a change in our relationships with the natural systems that support us. At the same time others argue that the problem is not as severe as presented, and that it is simply part of the process of human development (e.g., World Bank 1992; Goklany 2007). Some even suggest that the state of the ecosphere or at least 'the world' is improving (e.g. Simon 1981; 1991; Easterbrook 1995; Kahn 1998; Lomborg 2001; Goklany 2007).

Rising awareness of the problem and the increasing debate on the related issues has forced a discussion about the consequences of current trends, a discussion which has congealed around the now well known concept of "sustainable development". Since being popularized by the Brundtland report (WCED 1987), the term sustainable development has been defined in many ways in efforts to capture its interdisciplinary nature. In the process, sustainable development has become for many a kind of verbal 'magic bullet' that implies we can reduce our impacts on ecological systems while we continue to develop and improve the state of humanity. Sustainable development emphasizes human-nature relationships, and inter/intra generational equity relationships. Sustainability values and goals aspire to combine the ecological, social, and economical dimensions of life for the long run as well as for the short.

But are we on a sustainable course? A focus on the biophysical dimension of sustainability suggests that we are far from getting to safe-harbor. One important area of inquiry to forward the global sustainability agenda is an investigation of interregional interests and responsibilities for maintaining global ecosystems integrity: an interregional approach to sustainability.

1.2 The Research rationale

Human populations everywhere depend on both local and global ecosystems goods and services (e.g., clean air and water, food and materials). In recent decades we have witnessed a great increase in the spatial separation between human populations and the sources of the vital natural resources they consume. For most of human history, people supported themselves mainly on resources and assimilative capacities provided by local ecosystems. With increasing global economic integration this dependence has been extended to sources and sinks in distant parts of the world. As the world economy 'globalizes' trade has become a major mechanism by which much of the human population supports its needs. Globalization and trade enable people to free themselves from local ecological constraints by importing ecological goods and services; in effect, globalization represents the shuffling of biocapacity from regions with surpluses to other regions; some of which have by now greatly exceeded their domestic carrying capacities. This is problematic for several reasons: First, the spatial separation of material production (resource exploitation) from consumption eliminates the negative feedback that normally occurs when people dependent on local ecosystems degrade those ecosystems. Instead, "contemporary consumers remain blissfully unaware of any negative effects of their consumption on supportive ecosystems located half a planet away" (Rees 2006). Second, while globalization and trade allow many regions to develop, it also increases their vulnerability to the ecological degradation of supporting regions and to geopolitical instability anywhere that might jeopardize vital trade linkages. In short, excessive trade dependence might jeopardize the long term sustainability of dependent populations. Still, in today's world, trade is essential and can benefit societies around the world. Both positive and negative economic and ecological consequences of interregional connections must be explicitly documented and accounted for along the road to global sustainability.

At present most environmental reports and sustainable development studies apply to a single spatial scale: local, national or global. These reports analyze diverse pressures on human well-being and ecosystems integrity and suggest policies needed to achieve local or global sustainability (e.g., UNEP 2007; MEA 2005). The main emphasis is on the pollution impacts of production: the negative effects of production activities on local producing regions and in some cases on the global commons. Several authors (e.g., Rees 1995; Princen 1999; Conca 2001; Princen et al. 2002; Dauvergne 2005b) argue that the production approach is not sufficient and a consumption approach is needed as well. Indeed, examining economic activity and human development from the perspective of resource consumption can open our eyes to novel aspects of the sustainability problem. Although ecosystems degradation is a complex processes with multiple causes, loss of ecosystem integrity in almost any given region of the world can be attributed to both local and international consumer demands. In certain cases eco-degradation is significantly due to overseas demand for crops, meat, timber, minerals and other resources. The increasingly complicated web of trading relationships is essentially invisible to consumers, as are the negative ecological impacts of their consumptive demands. Lack of awareness and of negative feedback from ecological degradation encourages further consumption and further deterioration of ecological systems. The consumption-based approach to analyzing sustainability raises important questions about responsibility and accountability: in whose interest is it to sustain productive ecosystems? Who should be responsible for the ecological impacts generated through material and product trade? Should the cost of maintaining ecosystem integrity be born only by producers (i.e. exporters) or should the terms of trade be adjusted so that consumers (i.e. importers) assume some of the cost as well?

This study is based on the premise that sustainability requires living within the means of nature (Daly 1990; Holdern et al. 1995; Robert et al. 1997; Rees 2002b; Wackernagel et al. 2002). For sustainability we need an interregional approach that will provide us with negative feedback about our actions and that will highlight our dependence on others. In the global village what is out of sight should not be out of mind, what is far from the eye should not be far from the heart.

A major implication of increasing interregional dependences is that the spatial scale for sustainability analysis and planning must be changed to match the scale of human economic activities. Since we are creating a global village and a global economy we must ensure that both are sustainable at the global scale. Globalization should not serve to buffer consumers from the negative impacts of material-intense lifestyles; it cannot be allowed to short-circuit the negative feedback that consumers would normally experience from over-exploitation of their local supportive ecosystems. Ecological sustainability in such an interconnected world demands a more explicitly interregional analytic framework, one based on recognition that sustainability anywhere is linked, directly and indirectly, to sustainability elsewhere. These considerations should compel the world community to embrace an 'interregional human ecological' approach to sustainability. Approaching sustainability conscious of interregional connections forces recognition that: 1) virtually every significant human population or country lives, in part, on energy/material flows to and from distant points all over the world; 2) continuous growth in such relationships has the potential to create unseen (by consumers) unsustainable burdens on productive ecosystems in distant locales; 3) ecological degradation in one region has the potential to jeopardize the sustainability of other regions; 4) consumers in importing regions, particularly regions with irreversible ecological deficits, therefore have an interest in ensuring that their supportive ecosystems in other regions are managed sustainably.

The processes described above suggest that consumers, businesses and governments all over the world have increasing interests in ensuring the sustainability of their supporting ecosystems in other regions. The logic behind this kind of self-interest or practical responsibility includes increasing evidence that we are approaching the limits of planetary carrying capacity (Meadows et al. 1972; 2004; MEA 2005; WWF 2006). The shift from an ecologically empty to an ecologically full world (Daly 1991), a world in which natural capital is becoming a limiting factor for human development and sustainability, can increasingly be connected to, geopolitical and security issues (Pirages and DeGeest 2004).

In the past few decades numerous methods have been developed to quantify the physical dimensions of human activities and to enhance our understanding of human dependence on the natural world. Tools such as material flows analysis (MFA), ecological footprint analysis (EFA), life cycle assessment (LCA) and physical input output tables (PIOT) are typical of methods designed to quantify the energy and material connections between the human enterprise and the ecosphere (Wackernagel and Rees 1996; Ayres 1998; Robert 2000; Daniels and Moore 2002). While these tools move us a step forward in our quest for sustainability, they generally fail to identify either the origins of critical resource flows or the ecological changes that resource exploitation imposes on exporting regions. This study illustrates how to fill this analytic gap. I develop and explore an interregional model of sustainability that incorporates elements of MFA, EFA, LCA and PIOT.

1.3 Research questions and objectives

This research documents two major characteristics of interregional human ecology: (1) various importing nations' dependence on ecosystems within other national territories (2) the impact of these relationships on ecological integrity within the exporting countries. The overall research purposes are: (1) **To reveal the implications for sustainability of the increasing material entanglement among nations that result from accelerating globalization.** (2) **To describe and quantify the interregional material linkages between selected countries with a view toward documenting: a) the extent that trade flows can increase the material dependence of country 'A' on country 'B'; b) the linkages between material consumption in country 'A' and the loss of integrity of supporting ecosystems in country 'B'.** In short I examine the ecological impacts of resource consumption by specific import-dependent regions on ecological integrity in corresponding export countries. Thus, a central research questions are: (1) **How can inter-regional ecology and disaggregated eco-footprint analysis be used to illustrate the extent and intensity of inter-regional connectivity and thus provide the basis for assessing the local and international implications of globalization for sustainability?** (2) **What are the linkages between the loss of ecological structure and function in exporting regions and material demands in importing regions?**

More specific research objectives are:

a) To create a conceptual tool that will trace material flows and characterize the external ecological footprint of importing regions.
b) To add a potentially important dimension to the ongoing discussion of sustainable development and sustainability planning by developing an interregional ecology approach to sustainability.

In order to address the above research questions and objectives, certain technical questions need to be addressed:

a) How can available data sources be used to identify the geographic origins of the resource commodities that are consumed by specified consumer countries?
b) To what extent is it possible to quantify the amount of inputs (i.e., land, water, and chemicals) involved in the production of export products in different exporting countries?
c) To what extent is it possible to trace the connections between production of export products and ecological impacts?

1.4 Scope of the research

In this research I make the first steps in exploring, developing and documenting an interregional approach to sustainability. This research documents one part of a complex worldwide network of such interregional relationships. The interregional linkages analyzed here are at the international / global scale. The study employs case studies to analyze three kinds of interregional relationships and their ecological consequences: import relations; export relations; and product relationships. The study is necessarily illustrative rather than comprehensive, focusing mainly on production and trade of renewable resources, mostly agricultural products.

I recognize that such interregional connections also occur at other scales including the sub-national (i.e. the metabolism of cities is often sustained by distant regional or national sources of supply). However, because most data on consumption and trade flows is available only at the national scale, the illustrative interregional connections explored in this study are between nations

The United States serves as a representative importing nation. I trace resource flows of major renewable resources into the U.S. to their sources; compile the quantities from each source, and estimate the area of land devoted to production for U.S. consumers (i.e. the external material footprint of the United States). I then focus on two exporting countries, Costa Rica and Canada. I identify specific commodity flows from these countries to the rest of the world (including the U.S.), establish the amounts and types of physical inputs involved in resource production for each commodity, and explore connections between growing / producing the products and various ecological consequences of that production. The scope of analysis is at both the national / regional level and at the product level. Because ecological change processes are not generally a consequence of pressures in a single year, but rather of pressures over many years, the research follows the flow of resources and some input requirements throughout more than a decade, starting from 1989 to 2005. Such a multi-year approach makes it possible to connect production for export to some ecological changes.

1.5 Structure of the dissertation

This dissertation is divided into theoretical and empirical sections; each section is divided into chapters discussing different aspects and case studies of interregional ecology. In the theoretical section (chapters II-V) I develop an interregional ecology approach to sustainability. Chapter 'II' presents and analyses an interregional approach to ecological changes, I discuss different perspectives on the connections between human activities in any region and the ecological consequences in others. In chapter 'III' I discuss the processes of globalization and trade as the context for the interregional approach. In chapter 'IV' I bring in the concept of sustainability - I present the background and different perspectives on sustainability and make the connections between sustainability and interregional ecology in a globalizing world – building the argument that in a globalizing increasingly interconnected world the sustainability of one region depends on and impacts other regions' sustainability. Finally, in chapter 'V' I present the model developed and employed in this study and discuss the importance of such tools as ecological footprint analysis and materials flow analysis to the method.

The empirical section tests the above research ideas through application to three case studies. The research methods chapter (chapter VI), lays out in detail the interregional model developed here, identifies the assumptions made and some of the limitations of the study. In the following three chapters I examine different aspects of the interregional ecology model. Chapter 'VII' employs the consumer perspective by quantifying the material flows from around the world that enter the United States, and tracing the major sources of a large group of agricultural products and other renewable resources consumed in the U.S. I then quantify the amount of land required for growing each of those products. This chapter identifies different regions of the world with which the U.S. has interregional connections. While it accounts for the size of the external material footprints on each source, which implies potential pressure on eco-systems, this chapter does not examine specific changes in the structure and function of ecological systems in these sources.

In the following chapters I take an exporter approach in order to address source - specific ecological changes, the two case studies examined here are Costa Rica (chapter VIII) and Canada (chapter IX). In each chapter I follow the flow of renewable resources from these exporting nations to countries around the world, quantifying the different physical inputs involved in production of those resources and bringing forward some of the connections between production for export and changes in the structure and function of ecological systems in those case study nations.

Finally, in chapter X, I summarize the research findings, their implications and different potential implementations of the results and the interregional approach to sustainability and planning for sustainability. I also discuss different potential directions for future study that will develop the approach presented and studied here.

1.6 Significance of the study – contribution to knowledge

The study makes the case that for sustainability in an interconnected, increasingly globalizing world, conventional, primarily local pollution oriented perspectives on sustainability are insufficient. I argue that our focus must be widened to include material consumption and to broaden the spatial scale. I advance the argument that, in a globalizing world, no human society / business enterprise / country can be sustainable if its distant supporting hinterlands—other regions that may be half a planet away—are not sustainable.

I make the first steps in developing a theoretical basis of an ecologically oriented interregional approach to sustainability. This adds a missing trans-national dimension to the sustainability debate effectively integrating the policy domain for sustainability in one region with that in others. However, my research focuses mainly on documenting the nature and magnitude of interregional connections not on details of their policy relevance.

A significant potential contribution of this dissertation is the attempt to comprehensively document the material linkages between countries, to quantify and explore the connections between consumption in one region and some of the ecological consequences of production in another. It accounts for some of the 'externalities' of globalization and international trade. I follow trade flows, measure physical inputs involved in production of trade products and highlight some of the linkages to pressure on the ecosystems in exporting countries.

In developing an interregional calculation procedure I was inspired by such methods as MFA, EFA, LCA and PIOT, which have been developed to enhance our understanding of human dependence on the natural world. While these tools move us a step forward in our quest for ecological sustainability, they generally fail to identify either the origins of critical resource flows or the ecological changes resource exploitation imposes on exporting regions. The method discussed here draws from and builds on these tools and has the potential to contribute to each of them. Still, EFA is the major tool elaborated. I develop a method that allows disaggregating the ecological footprint of any study region to the specific locations around the world, estimating the size of the footprint on each country.

We inhabit an increasingly globalizing and interconnected world, a world approaching the limits of planetary carrying capacity (Meadows et al. 1972; 2004; MEA 2005). Earth has become an ecologically full world in which natural capital is becoming a limiting factor for human development and sustainability (Daly 1991). The erosion of critical natural capital can therefore increasingly be connected to geopolitical and security issues (Pirages and DeGeest 2004) enhancing the value of documenting interregional connections. Such factors as climate change, 'peak oil', increasing population and higher demands for resources add to the pressures undermining geopolitical stability and make things more complicated for global sustainability, particularly for heavily trade-dependent societies. The kind of analysis presented and advanced here can help the international community to develop and implement more advanced, explicitly interregional policies and institutions for ecologically sustainable consumption, including strategies for co-management of production, ecologically sensitive trade agreements, and resource depletion taxes as necessary. These policies reflect the risk-averse strategy suggested by Pearce et al. (1989), that to conserve at least "what there is" of remaining natural capital for future generations.

Chapter II - Interregional Perspectives on Ecological Change

Ecosystems degradation and environmental change are complex processes with multiple causes. There is more than a single driver for almost any significant trend (MEA 2005: 114). While local degradation can result solely from local activities (e.g., population growth, noxious industrial processes, inadequate domestic governance/environmental policy, corruption, etc.), it can also be caused directly or indirectly by actions or activities in or by other countries (e.g., Schleicher 1992; French 2000; MacNeill et al. 1991; Mason 2005). Moreover, local ecological change, whether driven by local or international activities, can have implications on processes of ecological changes in other regions as well. In this chapter I develop and analyses such an interregional perspective on ecological changes. I discuss different elements of such perspective supported by evidences from existing literature.

Most contemporary environmental studies apply to a single spatial scale: local, national or global. These reports analyze diverse pressures on human well-being and ecosystems integrity and suggest local or global policies (e.g. MEA 2005; UNEP 2007). Further, the main emphasis is on the impacts of production, the negative effects of economic activity on the producing region and sometimes the global commons. Oddly, the constant increase in resource consumption rarely attracts due attention as a factor in the ecological crisis (Rees 1995; Daly 1996; Princen 1999; French 2000; Dauvergne 2005b). I argue here that while such single scale production approach to understanding and analysing ecological change is crucial, in an interconnected world we need better to understand also the correlations between human activities (production and consumption) in one region and the impacts on other specific regions. We also need to understand the actual and potential consequences of ecological changes in one region on ecological systems and on human well-being in other regions.

Hall and Hanson (1992:15) explicitly discuss the growing need for societies to be aware of the state of and their impacts on the environment beyond the local scale. They argue that: (I) we cannot morally insulate ourselves from the problems of others; (II) because many environmental problems do not respect national boundaries no one is immune to the global effects of resource over-exploitation; (III) if we wish to have continued access to the products of ecosystems in foreign countries, it is in our best interests to see that these ecosystems are maintained.

2.1 Production, consumption and ecological changes:

Production processes have always been considered the source of various environmental problems, particularly waste and pollution. It is widely accepted that the producer is the polluter, and so if anyone should carry responsibility for pollution or any other damage it should be the producer. In recent years various researchers have identified the role consumption plays in ecological changes (e.g., Rees 1995; Daly 1996; Duchin 1998; Princen 1999; 2002; Clapp 2002; Dauvergne 2005b). They have argued that consumption is a key starting point for understanding human impacts on the ecosphere. Environmental degradation can be traced to the behavior of consumers either directly, through activities like the disposal of garbage or the use of cars, or indirectly through the production activities undertaken to satisfy them.

The ecological consequences of material and energy consumption can be experienced at local and/or global systems levels, and can be negligible or severe depending on factors such as the amount of consumption, the origin of consumption products, and extraction methods (Princen et al. 2002). Changes of ecological systems can be investigated from both production and consumption perspectives (Princen 1999; 2002). For example: (1) Increasing rates of greenhouse gas emissions from industry in China are commonly studied from a producer perspective, focusing on the rise of industrial production in that country. A consumer approach on the other hand would ask who consumes the products produced by China's industry, and might suggest that the increase in China's emissions is also the result of rising consumer demands. (2) Converting rain forests into soy bean fields in Brazil can be understood from a producer approach as the result of increasing agricultural activity in that country, and of local agriculture policy. However, it can also be viewed as a result of increasing local and international demand for soy products.

According to Holdren and Ehrlich (1974), human ecological impact can be estimated as a function of population, affluence levels, and available technology (I=PAT). Dietz and Rosa (1994), and Ekins and Jacobs (1995) modify this identity to speak of consumption specifically rather than affluence, yielding the equation I=PCT. This relationship implies that the more we consume the greater our ecological impact. While the above equation is a simplified presentation of the cause of ecological degradation, it summarizes some of the main factors. Consumption of energy and materials creates major ecological burdens throughout the world, and population affluence is directly related to levels of consumption (Myers and Kent 2004).

2.2 Three strands of 'interregional ecology'

I distinguish among three strands of thinking about relevant biophysical relationships – three strands of thinking of interregional ecology: *the conventional production strand, the local production / consumption strand and the trade flow strand*. All three refer to complex relationships between production and consumption activities in one region and ecological changes in others. (I) The *conventional production strand* focuses mainly on *pollution* outputs – e.g., the impact of waste emissions across boundaries. (II) The *local production and consumption strand* focuses on local ecological change that result from local drivers, but nevertheless jeopardize ecological systems in other regions as well as the interests of societies in other regions. (III) *The trade flow strand* examines the flow of resources (i.e., trade) from one country to another (or multiple others), the required physical inputs for the production of those trade goods, and the resulting pressures on ecosystems in exporting regions.

The following section further distinguishes among these interregional ecological realities and describes the role each plays in global ecological change. I then analyze the complexity of interregional ecology with a thorough discussion of the trade flow strand, the focus of this dissertation.

2.2.1 The conventional (pollution) strand

Corbin et al. (2000:11) discuss "spatial interaction" – how an event in one location or region can lead to a change in another location or region some distance away. Several 'environmental' problems conform to this description, such as transboundary pollution between neighboring states, the Trans global shipment of hazardous wastes, and even such "global" issues as the depletion of the ozone layer and climate change. As implied by these examples the literature divides these spatial interactions into three categories: transfrontier pollution, long-range transboundary pollution, and global pollution (Schleicher 1992; Okowa 2000; Kasperson and Kasperson 2001; Mason 2005).

(I) *Transfrontier pollution* – Transfrontier pollution is pollution from a specific source in one country that causes damage in another country (e.g. air or water pollutions transfer from one country to another). Transfrontier pollution has long been recognized as a factor that impairs relations between neighboring countries and it has received the most attention from authorities and researchers (Okowa 2000). Kasperson and Kasperson (2001:214) divide transfrontier pollutants into two subgroups: border impact risks and point source transboundary risks which are not necessarily located close to the border. In many cases both border impact and inland point-source pollution can be identified and directly connected to a specific activity or factory which discharges waste or contaminants into an international stream or water body.

(II) *Long-range transboundary pollution* – This category includes transboundary pollution from one or several countries (e.g. acid rain) that can be connected to specific damages in other, not necessarily neighboring countries (Kasperson and Kasperson 2001). This kind of transboundary impact mostly involves air pollutants resulting from industrial activities, transportation, and other energy intensive activities. The 1979 "Convention on Long Range Transboundary Air Pollution" defines it as:

> "Air pollution whose physical origin is situated wholly or in part within the area under the national jurisdiction of one state and which has adverse effect in the area under the jurisdiction of another state at such a distance that it is not generally possible to distinguish the contribution of individual emission sources or groups of sources" (cited from Okowa 2000).

(III) *Global pollution* – This group includes pollution from human activities in any or many regions that result in changes to globally-functioning biogeochemical systems so that the damages are essentially universal (Mason 2005). In short, this type of pollution degrades the global commons (Pearce 1995). Though in certain cases the location of the pollution can be identified and connected to specific acts (e.g., a certain corporation dumping hazardous waste into the ocean), in many cases it is impossible to make a direct connection between particular activities and specific impacts. This category includes pollutants such as CFCs that deplete the ozone layer, and greenhouse gases driving climate change (Mason 2005).

As noted, transboundary and global pollution are well recognized and have received considerable attention over the past few decades (Mason 2005; Clapp and Dauvergne 2005). Their impacts have led to both bilateral and more widespread international environmental agreements (e.g., Montreal accord on ozone depletion) which aim to minimize polluting activities and the impact of transboundary pollutants (Barrett 2003; Mason 2005; Clapp and Dauvergne 2005). In contrast, both the local production and consumption strand and the trade flow strand developed in this dissertation, though referred to in the literature are still little appreciated.

2.2.2 The local production and consumption strand

The MEA (2003:37) provides a list of indirect and direct drivers to ecological change. The indirect drivers includes: demographic; economic; sociopolitical; science and technology; cultural and religious. These indirect drivers lead to more direct drivers of change such as: land use and cover change; species introduction and removal; technology adaptation; external physical inputs (e.g., chemicals); and resource consumption. Some of these drivers are connected to international and global processes while others are linked to local circumstances. As will be discussed later, the proportion of production for export has been increasing all over the world in recent years, but in many places the extraction of renewable resources is still mainly for local consumption (based on FAOSTAT 2007) and many local ecosystem degradation processes are a result of local activities and trends.

However, in an interconnected world those ‘local’ ecological changes resulting from local activities or events can contribute directly to global change that threatens ecosystems and human well being elsewhere or everywhere. For example, forest fires in Canada and Indonesia contribute to greenhouse gas accumulation and thus accelerate global climate change; deforestation for any economic purpose anywhere also contributes to biodiversity loss which is ultimately a global issue; the local use of toxic chemicals can lead to dangerous accumulations in distant food chains, putting predatory birds and mammals, including humans at risk (e.g., Toxic pesticide and industrial residues from ‘the South,’ particularly Asia, impair the ‘country foods’ diets of Canadian Inuit).

Moreover, while many local ecological impacts result from strictly local activities, these impacts may eventually reduce the local ability to continue producing export products for countries that rely on or even depend on the ecological goods from that source. For example, consider the effect of prevailing U.S. biofuels policy on its capacity to supply export markets for corn, grain and related products; consider water mismanagement in the U.S. Southwest and in California which, combined with climate change, threatens California’s cropland, a major source of North America’s table vegetables.

2.2.3 The trade flow (consumption) strand of "interregional ecology"

Dependence, impact and responsibility are keywords that capture the essence of the Interregional trade flow approach. In today's increasingly interconnected world, a country can easily become *dependent* on resources provided by ecosystems that lie beyond its domestic boundaries. However, the production of various consumer products has the *potential to degrade* the ecosystems and natural processes that directly and indirectly support the consuming population. This raises questions regarding *responsibility*: should not both producers and consumers take responsibility for the deleterious impacts of the production-consumption process? And how should this compound responsibility be recognized?

The trade based strand of interregional ecology is the focus of this dissertation research. In the following paragraphs I analyze trade flows with a view toward showing their increasing relevance to the overall approach of interregional ecology developed here. I begin by explaining the keywords that most characterize the trade-flow strand of interregional connectedness.

2.2.3.1 Dependence

"*The relation of having existence hanging upon, or conditioned by, the existence of something else"* (Oxford Dictionary 2007).

Evidence and acknowledgment of the connections between human life and its supporting ecosystems has been gathered for different scales, from the very local to the global (e.g. Osborn 1948; Mooney and Ehrlich 1997). The simple fact is that human beings depend upon ecosystem services. Recently the MEA (2003:53; 2005) has defined ecosystem services as the benefits people obtain from ecosystems. Costanza et al. (1997:253) divide it, as is commonly done, into goods and services: "Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human population derive, directly and indirectly, from the ecosystem function". Daly (1997:3) divides ecosystem services to humans into: "(I) the production of ecosystems goods, such as food, timber, biomass fuels, natural fiber, forage and more; (II) Life support functions such as cleansing, recycling and renewal of what was used already; (III) Mitigating and moderating extreme phenomena such as climate, floods and droughts". The ability of ecosystems to support us is strongly connected to the wellbeing and health of those ecosystems (Rapport 1998; Prescott 2001). Ecosystem wellbeing depends on the system's capacity to maintain itself through cycles of growth, maturity, death and renewal, as well as its' productivity and the chemical and physical integrity of soil, water, and the atmosphere (Prescott 2001:59).

> Costanza et al. (1991:9) write: “An ecological system is healthy … if it is stable and sustainable – that is, if it is active and maintains its organization and autonomy over time and is resilient to stress”.

Human dependence on earth’s ecosystems has not declined over time but in some respects has increased. First, we consume more than we did in the past, both as individuals and in the aggregate (French 2000; Meadows et al. 2004; MEA 2005; Brown 2006; FAOSTAT 2007). This means that we depend on ever larger amounts of resources and ecosystems goods, a fact that influences the ability of ecosystems to support us. Another key change is the source of the natural resources we consume. For most of human history, people commonly used local resources produced by local ecosystems. More recently we have become dependent on resource supplies from all parts of the world (Princen 1997; 2002; French 2000; Rees 1994; 2004; WTO 2006). This increased dependence upon trade goods effectively increases the dependence of people in one region on ecological goods and services from another, thus extending the importing populations ‘ecological footprint’ (Rees 2006).

Interregional dependence:

The level of dependence of any country on resources from other countries is a function of many bio-physical and social factors. Bio-physical factors include the size of the importing country, its climate, and the quality and quantity of its local natural resources. Social factors include demographic characteristics (e.g. size, age and gender distribution of the population) and socio-economic factors such as wealth, education, material expectations as well as the dominant mode of production and extent of country engagement in globalization and free trade.

Wealth, population size and trade relationships create a particular kind of interregional connections between wealthy and poor nations. Varies authors address the connections between wealth and consumption, and between wealth and the demand for natural resources (e.g. Daly 1996; Rees and Westra 2003; Myers and Kent 2004; Dauvergne 2005b; Brown 2006). The wealthy nations of the world with 20% of the world population consume 50% to 80% of the world’s resources (World Watch institute 2004; Wuppertal institute 2007).

> “North America and Western Europe with less than 12% of the world population account for just over 60% of total private expenditure. South Asia and Sub-Saharan Africa, in comparison, with a third of the world’s population account for a mere 3.2 percent of total private consumption expenditures” (World Watch institute 2004, as cited from Dauvergne 2005b:37).

> “Europe’s ecological balance of trade […] is distorted; it imports more than three times the amount of energy and materials it exports. Moreover, EU countries shift environmental burdens to the South. Both ecological *rucksacks* of raw material imports and the pollution/energy-intensity of manufactured import goods have increased. Therefore, the perception of a clean and eco-efficient Europe largely rests on a rich country illusion“ (Wuppertal institute 2007:2).

Such figures show that local production in wealthy nations is supplemented by international flows of materials and goods, and that the people and economies of some countries have become dependent on overseas resources.

However, this dependence is more complex than implied by the simplistic view that the rich are consuming on the natural resources of the poor (Myers and Kent 2004). As populations in “transition economies” become more affluent, their consumption demands rise. Countries which in the past were mostly self-sufficient (albeit with a lower material standard of living) are eventually unable to meet the increasingly diverse and growing consumption demands of their populations and begin to depend upon resources imported from overseas. At the same time, they continue to deplete their own resources.

Due to the unique human and physical characteristics of individual nations outlined above, certain countries are virtually totally dependent on foreign resources and ecosystems for products and materials such as petroleum, minerals, and foods such as grains. Often, however, dependence relationships do not conform to the dictionary definition of the word *dependence*. In many cases the importing country does not absolutely require a certain product (e.g., bananas) and can live without it.

Although there are several reasons certain countries import products from other countries, my focus in this research is **not** on the reasons for specific import behaviour, but rather on the fact that when a country does import goods/products it ‘depends’ on the exporting country’s ecosystems to provide those goods. Interregional dependence is not only dependence on final products; it is also the dependence of one region on specific biotic and abiotic conditions in the distant producer region. These conditions allow the production to happen in the first place (e.g., Bananas in Costa Rica; wheat in Canada). However, to grow / produce products several physical inputs are needed (e.g., land, water, energy, chemicals). As will be discussed in chapter ‘VI’, it is the use of these inputs which directly and indirectly put pressure on the ecosystem, and risks its sustainability.

Various authors have acknowledged similar facets of such interregional dependence: As early as 1972, Borgstrom (1972:75) used the concept of *Ghost Acreage* to emphasize the ‘invisible’ cropland that some countries necessarily ‘import’ to supplement their domestic farmland. Odum (1975) identified extra land areas required by cities in energy terms. Siebert (1982) and Opschoor (1987) introduced the idea of *environmental space* which recognized that there is a limited availability of space on earth for both stocks (i.e. resources) and sinks (i.e. capacities to absorb waste) to sustain human needs. Folke (1988) investigated the extent of marine ecosystem area appropriated to sustain fish farming and fishing in the Baltic Sea. Cronon (1991) presents the idea of “nature’s metropolis”, where he discusses Chicago’s historic dependence on its surrounding nature and its environmental implications. Rees’ (1992, 2004) ecological footprint concept emphasizes the importance of distant hinterlands in the context of urban dependence on supporting lands. Brown et al. (2000: Chapter 25) discuss Costa Rica’s level of dependence on imported resources. Both, Brown (2006:9) and Hanson and Martin (2006:16) demonstrate China’s increasing dependence on overseas resources.

To accept the implications of interregional dependence, one needs fully appreciate the perspective presented here: modern life is ‘sustained’ on a continuous supply of large amounts of natural resources (i.e., ecosystems goods) that originate not only in local ecosystems but all over the world. The increasing volume of resource demand raises critical questions about the abilities of ecosystems to continue supporting the human enterprise. As consumers generally cannot see and often do not hear about the ecological conditions of distant ecosystems, it is hard to make the mental connection between their consumption and its impact on supporting ecosystems, wherever they may be.

2.2.3.2 Impact

The opposite of ecosystem stability is ecosystem degradation, in which the ecosystem becomes less able to support humans and non-humans with its services (Odum 1963). Ecologists look at ecosystems in terms of *structure and function*, which are strongly interconnected. Ecosystem structure refers to the ecosystem's components; both biotic and abiotic. Ecosystem function is the way the system's components interact and behave; the way the system self-regulates. Ecosystem functions are the ecosystem services that support human life. Nevertheless, modern techno-industrial society sees ecosystem structures or components, as mere commodities that can be used, bought and sold. Ecosystem structure and function are altered by natural processes, such as climate and geological forces, but increasingly major changes are induced by people.

Interregional Impacts

As discussed in this chapter, the common focus on environmental impact is mostly on the producer; in this case, the exporting country. From an interregional perspective, the consumption of imported products is thus a partial driver of ecological degradation of producer ecosystems. Daly (1997:1) discusses the use of ecosystem services and argues: "On a global scale, different groups of people are now living at one another's expense […]".

Interregional ecological impacts are a result of both: (I) the sheer volume of material flows between an importing country and its suppliers; (II) the specific ecological consequences resulting from resource (over)exploitation in these exporting countries. However, it is often difficult to discern how much of the total system degradation be ascribed to trade-dependence between nations. Growing or producing different products has different potential impacts. What is produced, the methods by which it is produced or harvested, and the specific location combined with the scope of consumption, determine the actual impact.

Various researchers have studied different dimensions of interregional ecological impact: Crosby (1986) identifies what he calls Ecological Imperialism, the historical 'biological expansion' of Europe between 900 and 1900. Tucker (2000) presents an historical perspective, mostly from the 19th and the beginning of the 20th century, on what he calls the U.S. role in the ecological degradation of the tropical world. His focus is on the U.S. imports of several agricultural products and the emergence of multinational companies which promoted that trade. MacNeill et al. (1991) presented the idea of "ecological shadows": certain countries' economic activities impose ecological problems on others. Dauvergne (1997) studied Japan's ecological shadow on south East Asia. He focused on the forestry sector, outlining the complexity of consumption and the political interests of individuals and multinational companies that contributed to deforestation. Myers (1981) presented the ‘hamburger connections’ where he argued for the connections between meat consumption in North America and deforestation in Central America. Henson and Martin (2006:16) discuss China’s increasing reliance on international commodity chains, focusing on such issues as soy beans from Brazil, palm oil from Malaysia and their connections to deforestation.

2.2.3.3 Responsibility

The acknowledgment that humans play an important part in ecological change raises several questions of responsibility. These include: Who is ultimately responsible for ecological degradation? Should the responsibility (and blame) be placed only on local actors and resource owners? If the production of export products imposes ecological impacts on the exporter, should not the importing country share the responsibility for that degradation? In whose interest is it to prevent or minimize ecological degradation? I argue that it is in the interest of both producers and also of foreign consumers.

Arguing for joint responsibility in the context discussed here is charged. Although global scale problems are increasingly recognized by the international community, international law assigns responsibility for resource management preventing ecological degradation to sovereign states (Barrett 2003). Countries have the right to exploit their natural resources for their own development (UNCED 1972). Hence, despite the existence of external drivers activities that lead to local ecological degradation are considered foremost an internal responsibility of local governments (Wapner 1998).

Recently we have become aware of the fact that local activities can create burdens at the global level and that the only way to address these problems is through global cooperation. This understanding has led to dozens of international agreements that attempt to tackle regional and global problems (Barrett 2003; Mason 2005). Nonetheless, mitigation of most environmental problems is still regarded as a national responsibility (e.g. reducing greenhouse gas emissions), and not an interregional one.

Interregional responsibility:

The increasing rates of globalization and trade in the last few decades have begun to foster dialogue about responsibility to ecological change (e.g., Litfin 1998; French 2000; Mason 2005; Brown 2006). There are two major reasons for import dependent nations to 'take responsibility' for distant ecological change: the issue is driven by both *moral responsibility* and by *practical self interest*. The first discussed in the following paragraphs while the latter is part of the discussion in chapter 'IV'.

Importing nations should assume **moral responsibility** for the consequences of their material demands on either ecosystem integrity or social welfare in exporting countries. If country 'A' imports from country 'B' and as a direct or indirect consequence, country 'B' experiences ecosystems degradation, country 'A' arguably has some moral responsibility for country 'B's ecological integrity. However, it appears from several trade disputes in the last few decades that countries are expected to stay out of other countries 'business' and are not expected to intervene even positively in areas of other states' sovereignty (Litfin 1998; Wapner, 1998). Even in cases where states try to show some kind of interregional moral responsibility they are frequently blocked by international free trade rules.

One of the most well-known examples is the 1980s U.S. - Mexico tuna dispute. In this case the U.S. banned tuna imported from Mexico because Mexican fishing methods harmed dolphins. GATT's Dispute Resolution Panel ruled in favor of Mexico, forced the U.S. to stop its ban, and argued that the U.S. had no right to interfere with the Mexican fishing practices. According to international law, countries are obligated to act and take responsibility in a case of human suffering, but they are not expected to do the same in cases of risk to ecological systems. Principle 12 of the Rio Declaration states that:

> "[…] Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of importing countries should be avoided."

States, individual consumers, and Trans-National Companies (TNC) are three major players whose activities contribute to ecological changes around the world, and therefore I believe should also assume some responsibility for ecological change.

States' responsibility – The interregional responsibility of states can be viewed from the pollution perspective or the trade flow perspective. As previously discussed, the pollution perspective focuses mainly on the negative results of cross-boundary pollution and polluter responsibility (Mason 2005). It is widely agreed and well documented that states are not allowed to negatively impact others' environments (UN 1972; 1992). Principle 21 of the Stockholm Declaration proclaims that:

> "States have …the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction of control do not cause damage to the environment of other states or areas beyond the limits of national jurisdiction."

By contrast the argument that states relying on import goods bear some responsibility for ecological damage resulting from harvest or extraction in producer regions, has not been accepted in the realm of policy-making or international agreement.

Consumers' responsibility – Consumers are not a single unit but rather a collection of individuals, each one making choices based on his or her personal preferences. It is the aggregation of consumer preferences and lifestyles that has the potential to either force a tremendous ecological impact or minimize it. States are limited in their willingness to take responsibility for interregional consequences of their actions, and they are engaged in restrictive international trade agreements. Individual consumers however, can take some responsibility for their actions by choosing certain patterns of consumption, and they can pressure their governments and TNCs to take responsibility for the interregional impacts of their activities. Like states, consumers' responsibility should be both moral and practical. It would be fair to say, though, that most consumers are not aware of ecological consequences of their lifestyles, and therefore have no incentive to alter their consumption patterns, or to push their governments and the supplying TNCs to make significant changes.

Trans-National Companies' (TNC) responsibility – Within the last few decades a relatively small number of large TNCs have become dominant in the global economy (Brown 1972; Buckman 2004), and act as catalysts for increasing globalization (Buckman 2004). While headquarters of these TNC are mostly located within a few rich countries, their activities occur around the world and contribute to a wide array of ecological change. In many cases TNCs have greater power and resources than sovereign states (Brown 1972; Barrett 2003). Attfield (1999:24) argues:

> “ [TNCs] are frequently in a position analogous to that of middle ranking countries, for they alone often have power over issues such as the continuation or discontinuation of the cultivation of wetlands or the felling of forests”.

He further emphasizes the lack of responsibility of many TNCs for the consequences of their activities:

> “…while the economic system may make them answerable only to their shareholders, the external costs of their operations may well affect people in all continents and for generations to come, and other species too.”

TNC activity is interregional. TNCs seek location advantages, for example, by investing in jurisdictions with minimal environmental regulation (Korten 1995). TNCs should practice interregional responsibility on moral and practical grounds. Indeed some TNCs have been engaged in voluntary corporate environmentalism (Hoffman 2001), exercising their corporate responsibility. Corporate responsibility comprises moral actions taken by firms that have some kind of commitment to ecological protection (Mason 2005). However, some argue that these are symbolic acts that do not come close to reducing the ecological impacts created by these companies (Korten 1995; Attfield 1999). TNCs should assume practical responsibility as well; in a ‘full world’ with limited opportunities for substitutions, an ecological change in one place can jeopardize the continued vitality of TNCs and their ability to supply consumer demands.

Chapter III - Globalization, Trade and Ecological Change

In this chapter I focus on two aspects of modern economic activity: *globalization* and *trade*. Both are highly relevant to the development of an interregional ecology approach. These two themes are interrelated and 'feed' each other; globalization encourages and advocates trade, and trade (particularly free trade) is a key driver of deepening globalization. Separately and together the two are both positively and negatively connected to the state of supporting ecosystems all over the world. I discuss the two concepts and outline their potential benefits and shortcomings. I then examine some of the connections between globalization, trade and ecological changes, and discuss the extent to which globalization and trade facilitate or hinder those systems.

3.1 Globalization

Globalization is a major trend at the beginning of the 21st century. Dozens of books and articles have been written about the process, and it has been defined in many ways. Some of these advocate the process, highlighting the benefits of globalization, while others emphasize its problematic nature. As a result of this dichotomy, the following questions become important: What is globalization? Why do we need globalization? What are its costs? And what are the connections to ecological changes?

Close to a hundred definitions of globalization currently exist (Das 2004). Although these definitions vary, there are many common elements:

"The term implies increased linkages across national boundaries, expansion of the international market economy, and a complex and integrated world society" (Lechner and Boli 1999; as cited from Lofdahl 2002:5).

Speth (2003:1) defines globalization as:

"Compression of the world and the tightening of all the linkages – economic, political, social, and environmental – between developments here and events in far corners of the world."

Friedman (2002:64) also uses spatial terms to describe globalization, defining it as:

"The integration of everything with everything else… of markets, finance, and technology in a way that shrinks the world from a size of medium to a size of small."

The integration of the spatial dimension with the issue of time and speed of events is also central to the concept. It has been emphasized that technology is a major component in globalization (Speth 2003).

Probably the first and most famous description of the phenomenon was by McLuhan (1962) who described the world as 'Global Village', and argued that by using advanced technology we shrink time and space. Clapp and Dauvergne (2005:20) write:

"In simple terms globalization means that the events and actions in one part of the world are affecting people in distant lands much more quickly, and with greater frequency and intensity."

Although there are many other variations on these themes, most definitions recognize world-wide economic integration and increasing connections between activities in certain places and activities/changes/impacts in other places.

Although the use of the term globalization has been fashionable since the 1990's, the process itself started long ago (Speth 2003). It is widely thought to have begun at the 1945 conference at Bretton Woods, New Hampshire, which led to the creation of the 'Bretton Woods institutions' – the International Monetary Fund (IMF) and the World Bank (Mander 2003). But globalization can also be seen as sourced from much older processes such as modernization and colonization (Clapp and Dauvergne 2005). It accelerated with the European age of exploration, the colonial period and the development of technology that expanded international commerce and exchange (French 2000). Some see globalization as an extension of imperialist and colonialist processes and a way to maintain the current hegemony of the west (e.g., Shiva 1993; Isaak 2005). Robertson (2003) describes three main waves of globalization. The first of these began with Columbus's (1492) and Da-Gama's (1497) 'explorations' and ended before the industrial revolution. The second was a result of the industrial revolution (the 18th century) and continued until the start of the Second World War. The third wave began at the end of World War II and continues today.

Buckman (2004: chapter 4) discusses the 'engines of globalization'. He recognizes three major engines: (I) Trans-national corporations (TNCs) which control most of the investments, trade and employment decisions in many countries around the world; (II) The international financial institutions (e.g. IMF, World Bank, WTO), created to oversee the management of economic globalization, which therefore have tremendous impact on globalization processes; and (III) Perhaps most important, are the world's governments which continue to push forward the current processes.

3.2 The case for and against economic globalization

Currently, most mainstream economic analysis and the leading economists favor globalization (e.g., Das 2004; Bhagwati 2004; Stiglitz 2006). They see globalization as a wealth creator, arguing that the globalization of trade, finance, and investment will improve the lives of all people by increasing per capita gross domestic product. In short, globalization is being promoted as the means to lift millions out of poverty (Das 2004; Goklany 2007). Part of the logic behind this assertion is that globalization allegedly results in more efficient use of resources, resulting in higher productivity and faster rates of global economic growth (Bhagwati 2004). Advocates of globalization argue that globalization increases international competition as countries struggle for a larger share of global markets, making the economy more efficient. Competition and free trade contribute to national specialization, following the theory of comparative advantage (discussed further in the trade section), and specialization will further increase resource productivity and efficiency.

At the same time several authors question globalization because, while it creates wealth, the already wealthy population benefits most (e.g. Buckman 2004; Isaak 2005). Isaak (2005) argues that globalization might push millions into deeper poverty and that it carries negative environmental and cultural consequences. Daly and Farley (2004: chapter 18) challenge one of the keywords of globalization – *efficiency*. They argue that globalization is far from efficient, from their perspective three elements required for efficiency: (I) *A large number of nearly identical competing firms* is required, but in reality the global economy is controlled by a relatively small number of TNCs. (II) *Freely shared information and perfect knowledge of the market* are expected, but once again a relatively small number of firms (mostly from the wealthiest parts of the world) hold the patents (i.e., the monopoly) for producing and manufacturing advanced technologies and consumers remain ignorant of most market conditions. (III) Finally s*trong incentives to internalize costs* should exist, but what actually happens is that countries that internalize the social and environmental costs of production have higher prices and lose competitive advantage in international trade (Daly 2001; Daly and Farley 2004).

3.3 Trade

As mentioned above, globalization and trade are interrelated. Robertson (2003) emphasizes the theoretical connections between the two. Each 'wave' of globalization is connected to a period of increasing global trade. If globalization makes our world seemingly 'smaller', trade is one of the major mechanisms. If globalization is efficient, competitive trade is regarded as the major tool to implement this efficiency. If globalization is about creating wealth and increasing economic growth, it cannot happen without trade.

Human trade for distant resources is not a new phenomenon. From the dawn of history, people have been involved in trading goods and materials over long distances. This trade has played an essential part in the development of societies. Traditionally trade was supplemental to local self-sufficient production and consumption. Daly and Farley (2004:309) discuss local production for local consumption as a "cake" while international trade is the "icing". Within the last few decades however, the scale of demand for materials and goods has changed, and there has been an increasing shift in consumption from local sources to overseas sources (French 2000: chapter 4; Schutz et al. 2004). In certain cases the icing has turned into the main ingredient of the cake.

3.4 The case for and against free trade

Mainstream economists see trade, particularly free trade, as an important source of the wealth of economies (e.g., Bhagwati 2004). Free trade, like globalization, is promoted as a growth engine, a global wealth and prosperity creator (e.g., Beckerman 1995; Bhagwati 2004). Indeed, based on the increase of trade rates within the last few decades, specifically the increase of trade by the wealthier nations of the world, it seems that trade does benefit economies. Like globalization, free trade is also considered by economists to encourage efficiency.

Two economic theories explain the logic behind free trade and its potential benefits: *absolute* and *comparative advantages*. The basic assumption behind any trade is that it is voluntary - neither party is forced to engage in the trade (Daly and Farley 2004). The '*Absolute Advantage Theory'* originated by Adam Smith in 1776 suggests that if one country can produce certain products at lower absolute costs than another country, and another country can do the same for different products, each has an interest in trading with the other. Each country specializes in producing goods for which it has an absolute advantage. However, based on that logic, in cases where certain countries can produce many goods more cheaply than other countries, Smith argued that there is no basis for trade.

Ricardo (1817) argued against Smith: both countries can benefit from trade even if one country has absolute advantage for all goods. The key to understanding this is to look at the *'Comparative Advantage'* and not only at the absolute advantage. Comparative advantage is the ability of a firm/country to carry out a particular economic activity/produce a particular good more efficiently than another activity/good. This means that: if country 'A' grows oranges more efficiently than it grows bananas, relative to country 'B', and country 'B' grows bananas more efficiently than it grows oranges, relative to country 'A', then country 'A' has a comparative advantage in growing oranges and country 'B' has a comparative advantage in growing bananas and any trade of bananas and oranges between the two countries will benefit both. They can produce more of what they are relatively efficient in producing and import other products. Comparative advantage theory recognizes that even though a certain country can produce all its needs, it still can benefit from trading with another country if each country has comparative advantage in the production of certain goods. The idea is that by giving up on producing certain goods that some one else has a comparative advantage in producing, each trading party frees resources to specialize on those goods for which it has a comparative advantage. In theory, the increased efficiency will benefit both countries. Comparative advantage theory adds one of the most important dimensions to the free trade discussion in the field of economics (WTO 2007). Referring to the question of how both trading parties will gain equally from the trade, Ricardo argued that if a firm thinks it will not have gains from the trade it will not join it.

Daly and Goodland (1991) and Daly and Farley (2004) question some of the assumptions of free trade. First, when free trade adherents argue for more efficient production of goods, they generally refer to efficiency in terms of labor and capital input, ignoring other factors including various so-called "externalities". If a certain country extracts coal for trade reasons, the extraction creates problems such as depletion of the coal mine, pollution, various social costs, etc. Second, increased costs associated with transportation are largely ignored. It makes more sense to import oranges from Costa Rica than to grow them in the U.S. if the true costs of transportation are not reflected in the price. Third, the benefits of free trade are frequently confined to specific groups, "We are concerned that global economic integration via free trade will favor a privileged minority at the expense of the majority in both the industrial and developing countries" (Daly and Goodland 1991). The wealth free trade creates accrues to a few and by-passes those who need it most. Fourth, while specialization has some benefits, it carries several problems such as the loss of economic diversity and a reduction in occupational opportunities. Daly and Cobb (1989:213) argue for the fact that Ricardo's comparative advantage, which is one of the justifications for free trade, does not work in the modern world. For comparative advantage to function, capital must not be free to flow across national boundaries. Ricardo assumed that there would be no movement of capital; capitalists would have an incentive to invest in those sectors of their domestic economies in which the country had a comparative advantage. However, if capital can flow freely, then it is likely to go to those countries that have absolutely lower labour and resource costs, regardless of domestic comparative advantage.

As discussed above, trade is one of the major mechanisms of globalization, and globalization propels trade forward. The discussion continues by adding supporting ecosystems into the trade-globalization equation.

3.5 Globalization, Free trade, and ecological change

What are the relationships between globalization and ecological change? Does trade facilitate or hinder the state of supporting ecosystems?

Those who feel that globalization and free trade contribute positively to the state of ecosystems argue for the two major benefits of current processes: globalization and free trade as engines of wealth (Easterbook 1995; Simon 1996) and as catalysts for efficient use of resources (Das 2004; Bhagwati 2004). It is widely assumed in mainstream economics that poverty is a major source of ecological degradation (e.g., WCED 1987; Hollander 2003; Bhagwati 2004), thus globalization and trade are viewed as part of the solution (Bhagwati 2004; Das 2004). Further, it is argued that globalization and trade generate the necessary wealth to pay for environmental improvements (Beckerman 1995; Bhagwati 2004). The U.N Agenda 21 (chapter 2) supports the above arguments:

> “Environment and trade policies should be mutually supportive. An open, multilateral trading system makes possible a more efficient allocation and use of resources and thereby contributes to an increase in production and incomes and to lessening demands on the environment. […] An open, multilateral trading system, supported by the adoption of sound environmental policies, would have a positive impact on the environment and contribute to sustainable development.”

These allegedly positive relations between economic growth and the state of the environment are explained by the concept of the ‘environmental Kuznets curve’. The environmental Kuznets curve (EKC) is an analysis of relationship between levels of income per capita (i.e., per capita GDP) and environmental degradation (e.g., different sorts of pollution). The relationship has been interpreted such that in the early stages of economic growth, degradation and pollution increase, but beyond a certain level of income per capita the trend reverses. Thus, high-income levels of economic growth appear to lead to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of income per capita. As economist Wilfred Beckerman argued:

> “the strong correlation between incomes and the extent to which environmental protection measures are adopted demonstrates that, in the longer run, the surest way to improve your environment is to become rich” (Beckerman 1992, as cited from Rothman 1998).

The conclusion of most studies on the EKC hypothesis is that some environmental indicators do indeed show improvement with increased income, with or without an initial period of deterioration (Stern 2003), but that other, particularly globally important pollutants do not.

The other argument for the contribution of globalization and trade is increased efficiency. Advocates of globalization argue that global resource exploitation will become more efficient, and that cleaner technologies and standards will be distributed (Das 2004). If, indeed, globalization leads to efficient use of resources, then the process of globalization and the implementation of free trade reduce the human pressure on the ecosystems. It has also been argued that global corporations can play a role in improving the environment because they have the ability (which, in many cases governments do not) to spread advanced environmental management practices, technologies, and techniques around the world (Speth 2003). Theoretically then, advances will not only be implemented by wealthy nations, but by all.

Not everyone is convinced that globalization and free trade can benefit ecosystems. While it may be true that globalization and free trade increase wealth and efficiency; that increase leads to the consumption of more natural resources and the production of more waste (Rees 2002; 2004; Dauvergne 2005b). Globalization has extended consumer lifestyle and over-consumption to many more people around the world (Myers and Kent 2004). As described above, the ‘environmental Kuznets curve’ has been used to explain the positive connections between economic growth (assumed to be partly the result of globalization and free trade) and environmental improvements. However, that relationship is problematic. One major aspect the EKC ignores is the fact that economic growth means an increase in material / energy consumption (Rees 1995). Rothman (1998) further challenged the EKC hypothesis by highlighting the differences between production-based and consumption-based approaches. He argued that all cases where the EKC hypothesis seems to work focused on local production impacts rather than on consumption. In other words, as income increases two phenomena occur: first, cleaner production which does mean less local pollution, but second, increased consumption levels meaning more rapid depletion. Increased consumption is ignored by proponents of the EKC.

Daly and Farley (2004:331) question the efficiency argument for globalization. They point out that the real goal of globalization is not simply to produce what we currently produce more efficiently, but to keep increasing the scale of production, a proposition which is inherently unsustainable. They also highlight that integration into a global system gives us only one chance to see if the system works; we cannot compare different ways of living and their ecological implications. It has been also argued that globalization and free trade decrease the ability of national governments to regulate and cope with environmental management challenges (Speth 2003). While it is true, as argued above, that TNCs can implement advanced technologies and environmental management tools, they need incentives to do that; incentives that may not exist (Daly and Farley 2004). Countries are also expected to embrace national specialization although it can have potentially negative impacts on the ecological systems where it occurs. Countries with high rates of biodiversity and with considerable ecological assets may put their natural endowments at risk if they specialize. Specializing in certain field(s) might enhance comparative advantage in the short run, but it cannot promise advantage in the future (a sustainability approach looks ahead). Future changes in global preferences might leave the specific country with fewer trade options and without resources to diversify or to expand their practices.

3.6 An interregional ecology perspective on Globalization and Trade:

Both globalization and trade have been presented as positively shrinking the world (Friedman 2002). However, globalization can also increase the distance between cause and effect. As the separation between primary resource extraction and ultimate consumption widens, consumers are spatially insulated from many impacts of consumption (out of sight out of mind). In a globalizing world, commodity chains grow longer, more complex, and become more deeply transnational. As key decisions are removed from primary producers and costs are externalized, feedback on actors from the resource (e.g., land, fishery, forest) in both production and consumption is severed (Princen 1997; Princen et al. 2002). Several researchers have argued that in a world of globalized trade consumers are blind to the negative ecological effects of distant resource exploitation and production created in part by their own resource demands (e.g. Princen 1997; Conca 2002; Daly and Farley 2004; Rees 1994; 2002; 2004). By inhibiting knowledge, information, and contextual understanding of the production process, globalization may stimulate consumption (Princen 1997; Conca 2001). Consumers lack the information and incentive to behave ‘sustainably’ even if they would otherwise be disposed to do so (Rees 1994; Princen 1997; Conca 2002). In other words, although trade can be a positive mechanism, it also blinds consumers to the negative ecological consequences of trade (Rees 2002b). Moreover, Rees (1994) incorporates the concept of carrying capacity and argues that through trade, some countries import carrying capacity of other countries, in many cases at the long term expense of the exporting country's people and their ecological systems.

Indeed, as argued by the EKC, economic growth often leads to increased investment in reducing local consequences of economic activities such as air and water pollution; still, economic prosperity increases ecological impacts at other spatial levels through elevated consumption of overseas resources (i.e. interregional ecology), and through generation of cross-boundary emissions and wastes such as atmospheric carbon dioxide (i.e interregional ecology). Two examples of local policies that have interregional ecological consequences are:
(I) Forest conservation policies in China and Finland have contributed to increased rates of wood imports from Russia resulting in increasing deforestation in that country (Mayer et al. 2005:359).
(II) The introduction of the auto catalyst in Europe in the mid 1980's decreased transportation source air emissions and contributed to improving health in that region; however it significantly increased the emissions in Siberia where one of the major components of the catalyst (the metal palladium) is extracted (Schutz et al. 2004:36). These extra-regional negative impacts do not show up in Kuznets curve assessments, but are nonetheless real and important. So, while globalization and trade increase GDP, they create a different set of problems, sometimes on different set of scales.

Chapter IV - Interregional Ecology and Sustainability in a Globalizing World

In recent decades both human population and the world economy have grown dramatically. While material growth has contributed to human wellbeing in much of the world, it has also dramatically increased the degradation of critical ecosystems and related life support functions on every continent (UNEP 2002; MEA 2005). Rising awareness of the problem and the increasing debate on the related issues has forced a discussion about the consequences of current trends, a discussion which has congealed around the now well known concept of "sustainable development". Since being popularize by the Brundtland report (WCED 1987), the term sustainable development has been defined in many ways in efforts to capture its interdisciplinary nature. In the process, sustainable development has become for many a kind of verbal 'magic bullet' that implies we can reduce our impacts on ecological systems while we continue to develop and improve the state of humanity. Sustainable development emphasizes human-nature relationships, and inter/intra generational equity relationships. Sustainability values and goals aspire to combine the ecological, social, and economical dimensions of life for the long run as well as for the short. Since the term entered the mainstream vocabulary and became part of the discussion on humanity's future, it has been analyzed from different perspectives (e.g., Rees 1992; 1995; Norgaard 1994; Robert et al. 1997; Dale 2001; Adams 2001; Robinson 2001; 2004).

It seems that the more we discuss the concept the more complex it becomes. Often sustainable development combines environmental, economic and social dimensions to imply some kind of balance among these variables. It also describes a process by which humans should respond to the environmental and social crises facing us (Robinson and Van Bers 1996; Keiner 2006). Although different sectors and communities disagree about the usefulness of the concept of sustainability, it is internationally recognized (Dale 2001; Sneddon et al. 2006). Some even argue for the emergence of a new "sustainability science" (e.g. Kates et al. 2001; Clark and Dickson 2003; Reitan 2005).

My aim in this chapter is to connect the interregional ecology approach discussed in previous chapters to the concept of sustainability; emphasizing the importance of understanding interregional connections as part of the discussion on sustainability and development toward sustainability. I open with a short background of the concept. I then present some perspectives on sustainability and their connections to the interregional ecology approach and discuss the place of such an interregional approach to sustainability in current discussion on sustainability.

4.1 Background

The use of the term sustainability can be traced to the 1970s. Goldsmith et al. (1972) define a sustainable society as "one that to all intents and purposes can be sustained indefinitely while giving optimum satisfaction to its members." One of the results of the increasing awareness of environmental issues was the 1972 Stockholm Conference on Human Environment. Though the term sustainable development was not officially discussed, the Stockholm conference is recognized as a key event in the emergence of the sustainable development debate (Mebratu 1998; Adams 2001). The ideas behind sustainability as well as the discussion of sustainable development are connected to much earlier periods (Mebratu 1998; Dresner 2002). Several milestones are: the 'theory of limits' and the work of Malthus, who considered as the first economist to foresee limits to growth caused by resource scarcity; Schumacher's who questioned the scale of the economy and economic units (Schumacher 1973); and the 1972 Club of Rome publication, *Limits to Growth* that argued for the need to change our growth patterns and highlighted the limits of earth's natural systems to support humanity.

The IUCN used the term Sustainable Development (1980) as part of its *World Conservation Strategy*. They defined development as:

"the modification of the biosphere and the application of human, financial, and living and non-living resources to satisfy human needs and to improve the quality of human life".

They related development to sustainability:

"For development to be sustainable it must take account of social, ecological, and economic factors; of the living and the non-living resource base; and of the long-term as well as the short-term advantages".

A year later the World Watch Institute published *Building Sustainable Development* (Brown 1981). Brown argued for the need to look beyond short term environmental consequences and face up to the institutional changes required to create a society that would be able to stay indefinitely within environmental limits (as cited from Robinson 2001). The growing discussion of sustainability, specifically combined with development issues (i.e., "sustainable development"), drove the World Commission on Environment and Development (WCED 1987) to define sustainable development as:

"Development that meets the needs of the present without compromising on the ability of future generations to meet their own needs" (WCED 1987:43).

This definition popularized the concept and ever since, sustainable development has become part of the mainstream dialogue, internationally recognized and used on a daily basis (Dale 2001; Dresner 2002). Indeed, the 1992 U.N. Conference on Environment and Development (i.e. the Rio Summit) inspired by the WCED, put the concept of sustainable development under the world spotlight and promoted its ideas (Brown 1997; Adams 2001; Speth 2003).

Though ‘sustainable development’ has succeeded in uniting widely divergent theoretical and ideological perspectives into a single broad conceptual framework, various individual disciplines have established their own narrower definitions (Estes 1993; Drummond and Marsden 1999; Dresner 2002). Ever since its emergence, and particularly after it became part of the mainstream, sustainable development has been discussed and criticized by scholars holding different perspectives (e.g., Norgaard 1994; Rees 1995; 2002a; Daly 1990; 1996; Robert et al. 1997; Robinson and Tinker 1998; Drummond and Marsden 1999; Robinson 2001; 2004; Keiner 2006).

4.2 The Biophysical approach towards ecological sustainability

The biophysical approach towards sustainability is rooted in biology and ecology. Sustainability from this perspective can be defined as *living within the means of nature* (Daly 1990; Karl et al. 1997; Rees 2002; Wackernagel et al. 2002) which requires maintaining sufficient natural capital (Costanza 1991). This framework suggests four criteria for sustainability (Daly 1990; 1996; Robert et al. 1997):

(I) Not using renewable resources faster than they are replenished.
(II) Not using nonrenewable resources faster than renewable substitutes can be found for them.
(III) Not significantly depleting the diversity of life on the planet.
(IV) Not releasing pollutants faster than the planet can assimilate them.

Similarly, Simon and Ekins (1998; as cited in Neumayer 1999:193) provide a list of sustainability standards:

(1) stable climate; (2) Undepleted ozone layer; (3) Biodiversity at current levels; (4) No loss of function for non renewable resources; (4) Sustainable harvest at desired level of renewable resources; (5) Limiting emissions to critical loads in order to protect human health; (6) Maintenance of an un-spoilt countryside; (7) Maintenance of environmental security in restricting environmental risks to low levels.

Physical scientists and ecologists are accustomed to the idea of limits (Holling 2001). Natural systems must exist subject to the unyielding laws of thermodynamics (Odum 1997). Systems ecology explores the implications of these laws for living organisms (Kay 1991; Odum 1997). "Two of the fundamental axioms of ecological and evolutionary biology are that organisms are exuberantly over-productive, and that limits set by time, space, and energy are inevitably encountered" (Holling 1994). Thus, from an ecological perspective, sustainability must find ways to limit population and consumption levels. These ideas reflect an understanding that nature provides services to humans (e.g., Daly 1997; 1999; Myers 1991; 1997; MEA 2005; WRI 2007); acknowledgment that humans are not the only living creatures on this planet (e.g., Mooney and Ehrlich 1997); recognition that the earth's ecosystems have limited capacity to sustain them and us (Holling 1994; 2001); and that the ecosystems upon which we depend are complex systems which we cannot completely understand (e.g., Georgescu-Rogen 1971; Odum 1989; 1997; Holling 2001).

> " The ecosphere ability to sustain productivity and biodiversity of ecosystems, and thereby to sustain society with its demands for services and resources from the ecosphere, is dependent on very complex interactions between the various species within the ecosystems, and between the ecosystems and the surrounding geophysical world" (Robert 2000:244).

Ehrlich et al. (1977) and Robinson and Van Bers (1996:10) emphasize human dependence on nature's sustainability: "The health, well-being, and ultimate survival of our own species are linked to, and dependent upon, the health and sustainability of ecological systems". And "Sustainability requires that human development proceed in a way that maintains the long term health and productivity of natural systems". For sustainability, it has been argued humanity needs to find ways to live within nature's carrying capacity:

> "Man is like every other species in being able to reproduce beyond the carrying capacity of any finite habitat. Man is like no other species in that he is capable of thinking about this fact and discovering its consequences" (Catton, 1980:6).
>
> "Sustainability means improving the quality of human life while living within the carrying capacity of supporting ecosystems" (IUCN, UNEP, WWF, 1991).
>
> "Learning to live sustainably implies taking the measures necessary to ensure that all members of the human family can live satisfying lives within the means of nature (i.e. within the long term carrying capacity of the earth)" (Rees 2002b).

Carrying capacity is traditionally defined as the average number of individuals of a given species that can occupy a particular habitat without permanently impairing the productive capacity of that habitat (Rees 2002b). The human carrying capacity of a defined habitat is its maximum sustainably supportable load, and is a function of human population size and material/energy throughput (Catton 1980; Rees 2002b).

Malthus opened the modern debate on carrying capacity when he forecast limits to growth due to resource scarcity (Mebratu 1998; Rees 2002b). Malthus' thesis has been challenged and dismissed by many, particularly mainstream economists, because technology has thus far overcome immediate problems of resource scarcity at least for the wealthy elite. However, from the biophysical perspective of sustainability, the issue of carrying capacity remains very relevant.

Historically the discussion of human carrying capacity has been framed around two issues: population and resource consumption. Questions about population carrying capacity appeared in the 1960s with Ehrlich's (1968) book 'The Population Bomb' and population increase continues to be a major issue as highlighted by Cohen's (1995) book 'How Many People Can the Earth Support?'. Hardin (1980; as cited in Rees, 2002b:11) argued "Carrying capacity is the fundamental basis for demographic accounting". The second issue for discussion on carrying capacity was and still is of human material and energy use (Meadows et al. 1972; Catton 1980; Wackernagel and Rees 1996; Rees 2002b). Catton (1980) argued that human carrying capacity involves more than the number of people that can live. It is also about the ability of earth to support a growing human population and to satisfy that population's material demands. From this perspective the supportable population varies inversely with average per capita material consumption - i.e. with lifestyles.

While that biophysical approach to sustainability imply for the importance of interregional ecology perspective on ecological changes the discussion is still at the conceptual level and does not make explicit connections between the sustainability of one place and that of another.

4.3 The mainstream economic - centric approach towards ecological sustainability

Not everyone sees carrying capacity as relevant to sustainability; many economists and techno-optimists believe that the concept, as applied to modern humans, is defunct:

> "There are no limits to the carrying capacity of the earth that are likely to bind any time in the foreseeable future. … the idea that we should put limits on growth because of some natural limit, is a profound error and one that… would have staggering social costs." (Summers 1991: as cited in Rees 2002b).

> " with current and near current technology, we can support 15 billion people in the world at twenty thousand dollars per capita for millennia – and that seems to be a very conservative statement" (Kahn, in respond to the limit to growth 1972, as cited in Meadows et al. 2004).

Even the Brundtland Commission subscribed to this vision. The commission argued that global sustainable development can be achieved even with a five to ten-fold expansion in industrial activity by the mid 21st century on ground that as the global economy expands, trade and technology will be able to compensate for the depletion of natural resources and the loss of life support services. Indeed trade and technology are seen as the major mechanisms that make carrying capacity irrelevant to humans. The argument is that any human population that can trade surpluses of a certain resource for another resource is not restricted in population or economic growth by the limited carrying capacity of its own territory.

Low and Gleeson (1998) divide what they call "mainstream (i.e., reformist) sustainable development" into categories. Following their framework I will discuss the two major approaches: market environmentalism and ecological modernization. ***Market environmentalism*** sees the market as the most important mechanism for mediating between people and regulating their interaction with the environment. It involves a political agenda of 'rolling back' the state, deregulating markets and extending market relations into society and its relation with the environment. Market environmentalists argue that:

> "The 'green economy' will be a capitalist economy. And just as the economy theoretically reaches a level of equilibrium in which social needs are met, so the green economy will theoretically reach a level of 'sustainable development' in which the capacity of the planet to provide raw materials and absorbs wastes is not overstretched" (Low and Gleeson, 1998:81).

According to market environmentalism the further market exchange penetrates into the environment, the greater the efficiency of environmental management. Market environmentalism is the result of a growing engagement by economists in the sustainable development mainstream. This approach to sustainability follows the mainstream market liberal economics approach as presented by many economists (e.g., Solow 1974; Simon and Kahn 1984; Simon 1996).

While market environmentalism is the dominant force in mainstream sustainable development (Adams 2001; Rees 2002a) another approach has emerged: ***Ecological modernization***. Though this approach toward sustainable development is still very 'econo-centric' it recognizes and argues that the market cannot completely reflect the state of the environment or progress toward sustainable development (Beckerman 1994). Accordingly, the state, its institutions, and its ability to regulate the market are of critical importance. Ecological modernization takes a very similar approach to that of market environmentalism. Both believe in the value of economic growth, globalization, trade, foreign investment, technology, and the notion of sustainable development. Still, while the market environmentalism approach highlights the benefits of free markets, ecological modernization emphasizes the need for institutions and regulations to force the market to deliver on its promise (Adams 2001; Clapp and Dauvergne 2005).

Both, market environmentalism and ecological modernization approaches to sustainability focus on the problems of human organization rather than on any ecological limits. They emphasize human ingenuity and resilience to change. However, I believe that in order to make the required adjustments for sustainability, such as increasing prices, taxes etc. negative feedback from the supporting ecosystems should reach individual consumers and their governments. As discussed above the more we become engaged in a global economy the less we experience negative feedbacks and therefore do not recognize that we have a real interest in making a change.

A major distinction between the biophysical and economic approaches is their attitude towards the place and importance of the natural ecosystems for human sustainability. That difference is often presented under the terms of strong versus weak sustainability. Those who argue for strong sustainability (biophysical approach) see natural capital as essential to human sustainability; they demand that each natural capital stock is kept constant over time. On the other hand weak sustainability (mainstream economic approach) starts from the assumption that natural capital, human made capital, and human capital are close substitutes. Weak sustainability involves the principle of trade-offs between losses to natural capital in one project and gains elsewhere, and the substitution of either human made capital or human-induced natural capital for lost natural capital.

In the context of this dissertation, a problem I see in the weak sustainability approach is that quite often increasing human capital in one region results in declining natural capital in other parts of the world. Moreover, while it is true that natural capital can be used for increasing human well-being, as discussed in previous chapters, that well-being is strongly connected to maintaining a sufficient amount and quality of natural capital. In other words, for sustainability, the substitutes of natural capital with other forms of capital should be within the boundaries of the natural system.

4.4 The ecological economics approach towards sustainability

> "Ecologists study non-human species and the ecosystems that sustain them by measuring and analyzing the physical flows of energy, material and information essential to the continuous restructuring and self-organization of those systems. By contrast, most economic analyses are money-based. They ignore both the biophysical context of the economic process and the behavioral dynamics of ecosystems within which it takes place." (Rees, 2000:4)

Various authors argue that current economic systems do not reflect the function and behaviour of our natural life support systems, nor do they recognize that all human economies are dependent upon nature (e.g., Boulding 1966; Georgescu-Roegen 1971; 1977; Daly 1973; 1991; 1996; Costanza and Daly 1987; Costanza 1991; Rees 1992; 2000; 2002a; Norgaard 1994; 2001). The emergent field of Ecological Economics challenges the mainstream economics approach to sustainability by emphasizing the dependence of social and economic systems on ecological systems and by characterizing the economy as an integral part of the natural environment (Costanza 1991; Rees 1995; Daly and Farley 2004). Ecological economics attempts to bridge the gap between the field of conventional ecology and mainstream economics.

> "From the relative objectivity of ecology, humankind's fundamental relationship to the rest of nature is functionally similar to that of the millions of other species with which we share the planet. Like other organisms, we survive and grow by extracting energy and material resources from the ecosystems of which we are a part; like them we "consume" these resources before returning them in altered form to the ecosphere. Thus, far from existing in splendid isolation, the human economy is and always has been an inextricably integrated, completely contained, and wholly dependent sub-set of the ecosphere" (Rees, 1992:6).

The Ecological Economics approach to sustainability confronts one of the fundamental basics of mainstream economics – economic growth. Ecological economists argue that economic growth means growth in material and energy consumption, and that these expansions are not infinitely sustainable. Also they argue that development does not necessarily mean growth.

Hence, the concept of sustainable development offers an alternative to conventional growth-oriented thinking (Sneddon et al. 2006:260). One ecological economics definition of sustainability regarding the limit of material growth is "the amount of consumption that can be continued indefinitely without degrading capital stocks including natural capital stocks" (El Serafy, 1991:168).

> "Sustainability is a relationship between dynamic human economic systems in which: human life can continue indefinitely; human individuals can flourish; and human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the diversity, complexity, and function of the ecological life support system" (Costanza 1991:9).

> "[…] development without growth – a physically steady-state economy that may continue to develop greater capacity to satisfy human wants by increasing the efficiency of the resource use, but not by increasing resource throughput" (Daly 1992:333).

In summary, the ecological economics approach to sustainability combines the biophysical and economic approaches. It highlights the need for such interregional approach, the need to quantify and document the flows, their connections to ecological changes and to make sure that we are living within the means of nature.

Ecological economists have brought up several ideas for sustainability; some are very relevant to this dissertation. For example Costanza (1991) Norgaard (1994) and Daly (1999) suggest that:
(I) ecosystems goods and services must be **incorporated into economic accounting** to support decision makers with a comprehensive picture of the reality.
(II) We need to consider **material and energy balances** and to devise ways of **keeping track of multiple material and energy flows**.
(III) We need to continue learning and understanding **the consequences of human activities** on the ecosphere, both for the short and long run.
(IV) We need to learn how **different scales of human activities interact**, and how we might construct **multi-scale operational definitions of sustainability**.

These ideas will be developed and explored in detail in the following chapters.

4.5 Integrating an interregional ecology approach and sustainability:

"The spatial scale of sustainability must be global; human society within the biosphere. However, all tools and approaches seem to set system boundaries according to geographic or administrative borders and boundaries. The use of system boundaries is understandable to the extent it enables analyses and evaluations that are not left undone due to too heavy data, financial, human and time resource requirements. But this cannot be acceptable if the definition of the system boundaries and exclusion of aspects support decisions in organizations, in public policy and business management that contribute to unsustainability" (Korhonen 2006:3).

What is the appropriate scale at which to deal with sustainable development? Should it be local, regional, national or some other scales? (Costanza 1991; Daly 1992; Rees 2000) The issue of scale has been debated ever since the sustainability concept came under discussion.

Researchers in the natural sciences (especially the field of ecology) have long realized the importance of scale (Gibson et al. 2000). Scale is defined as: "the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon" (Gibson et al. 2000:218). When dealing with ecological change, and more particularly the reasons for change, the issue of scale rises again. The UN Millennium Ecosystem Assessment (MEA 2003) investigates the scale at which ecological systems and ecological phenomena should be studied and monitored. It makes a distinction between two kinds of scales: *scale of observation* and *scale of the phenomenon*. The scale of observation is a construct based on human systems of measurement. Its components are: extent, resolution, and grain (Bloschl 1996 as cited from MEA 2003:107). The extent refers to the total area / time over which the phenomenon is observed. The resolution is the interval or distance between observations. The grain is the area or duration of single observation. The scale of the phenomenon refers to the phenomenon itself; (MEA 2003:108). The scale of the phenomenon may be much larger than the scale of observation depending on the extent of the scale of observation (i.e. certain phenomenon will be monitored within the country boundaries but the consequences of that phenomenon have impact on a much larger region). That leads to a multi-scale approach (MEA 2003; 2005) which simultaneously uses larger and smaller-scale assessments: "it can help identify important dynamics of the system that might otherwise be overlooked. Trends that occur at much larger scales, although expressed locally, may go unnoticed in purely local scale assessments" (MEA 2003:107). The logic is that fully to understand a phenomenon and to be able to track its results requires that a multi-scale approach be taken.

Debates on sustainability policy highlight a range of viewpoints on the appropriate scale for policy development and implementation. For example: Gardner (1990:337) argues for a bottom up approach in which decision making at the community level provides the framework for "achieving development to meet the needs/aspirations of the local population, respect cultural diversity, and maintain ecological systems". The bottom up approach argues for local scale activity. From that perspective, global sustainability will be the sum of many local sustainability activities. Others argue for a regional scale approach (Nijkamp and Soetemann 1988), claiming that local efforts alone are insufficient and a regional perspective is required when planning for sustainable development. For many, the nation state is considered the dominant scale at which decisions should be made and strategies implemented. IUCN et al. (1991) "Caring for Earth" report advocates a nationally based approach to sustainable development. The authors of the report agree that local and regional measures should be taken, but argue that the state should be responsible for promoting sustainability. Drummond and Marsden (1999:12) argue that "the national and supra- national state remains the locus of most regulation" and therefore sustainability policies should be implemented at that scale. Clapp and Dauvergne (2005:70) emphasize the important role states have in creating ecological problems and in governing their solutions. Hence, most of the international discussions on sustainable development are at the national level (e.g., the UN summits, Agenda 21, the Kyoto accord etc.). The general assumption is that the sum of countries taking sustainable development action will eventually lead to global sustainability.

While all these scales are central for promoting sustainability, in an interconnected world where activities in one place create pressures on other places, where life in one location depends on the flow of resources from many others, I would argue that it is probably not enough to analyze sustainability in a single local dimension scales such as individual cities, regions or nations. Rees (2000) suggests that the scale which we should address sustainability is the scale of economic activity. Since we have an increasingly integrated global economy, then that is also the scale we should address sustainability. To fully understand the sustainability related connections between different regions of the world, we need to add an interregional scale for analysis. I argue that such an interregional ecology approach to ecological changes as discussed in details in chapter 'II' is very relevant to the discussion on sustainability and development toward sustainability. It based on the premise that in a growing, globalizing, increasingly interconnected world, achieving local and global sustainability demands a more explicitly interregional-international implementation framework, one based on recognition that sustainability anywhere is linked, directly and indirectly, to sustainability elsewhere. It proposes that any given locale/region is dependent on the productivity and ecological sustainability of supporting regions, wherever on earth they may be located. Approaching sustainability conscious of interregional connections forces recognition that: 1) virtually every significant human population or country lives, in part, on energy/material flows to and from distant points all over the world, 2) consuming imported materials has the potential to create unseen unsustainable burdens on productive ecosystems in distant locales and, 3) ecological degradation in one region has the potential to jeopardize the sustainability of other regions.

Therefore the following definition incorporate the three strands of thinking at interregional ecology discussed in chapter 'II' with sustainability:

The conventional pollution strand:

This strand of interregional ecological thinking recognizes that economic production in one location of the world ***imposes assimilation burdens of useless waste*** *on ecosystems in distant locales (e.g. transboundary pollution). This perspective clearly recognizes that* ***sustainability in one place (or country) can be negatively affected by modes of production, sources of energy, material use, and transboundary waste flows of other countries.***

The local production and consumption strand:

This version of interregional ecological thinking recognizes that ***local production and consumption anywhere*** *that* ***leads to local ecological degradation may risk the sustainability of distant regions as well****. That is, in an ecologically interconnected world, changes in local ecological productivity may jeopardize the sustainability of countries that rely on imports from that region. Moreover, ecological degradation in one region (e.g. soil erosion, deforestation) may lead to changes in other regions (e.g. climate change).*

The trade flow strand:

This component of "Interregional ecology" recognizes that ***consumption driven demand*** *for imported materials in one part of the world imposes burdens on productive ecosystems in exporting locales. It recognizes that* ***the sustainability of human society in any given locale/region is dependent on the productivity and sustainability of supporting regions,*** *wherever on earth the latter may be located. Thus, irresponsible consumption anywhere can jeopardize the sustainability of supporting regions and ultimately of the consuming region as well.*

Following the discussion in chapter 'II' societies anywhere are dependent on a set of ecological goods and services originated from regions all over the world, production activities in different supporting regions deteriorate ecosystems in those supporting regions. I argue here that societies have **practical interests** for their own sustainability to sustain those supporting regions wherever on earth they might be. In the following paragraphs I will make some of the theoretical linkages between the interest societies have in sustaining overseas ecosystems and their own sustainability.

4.5.1 Interregional interests:

Responsibility driven by *self interest* (or *Practical responsibility)* is the responsibility a country has for its own citizens. If country 'A' has become dependent on country 'B' for vital resources, then the government of country 'A' has an interest, even an obligation to its citizens to ensure that producer ecosystems of country 'B' remain viable. Furthermore, if the production of export products in country 'B' leads to deterioration of ecosystems in that country, and risks different ecological services (e.g. biodiversity, climate mitigation) that support future production and other more global services, it should also be the interest of country 'A' to sustain those ecosystems in country 'B'.

The logic behind this kind of self-interest or practical responsibility can be framed by three major factors: (1) *the limits to growth in a finite world* (Meadows et al. 1972; 2004); (2) the shift from *empty to full world* (Daly 1991) and (3) the need to ensure *ecological security* (Pirages and DeGeest 2004). Each factor underscores the need for responsibility driven by self interest and the need for an interregional ecology approach to sustainability.

(1) *The limits to growth in a finite world* – At the beginning of the 21st century, after a century of increasing human activity, expanding populations and rising per capita material and energy consumption, the MEA (2005) presented a gloomy picture of the state of global ecosystems. Indeed "The limits to growth" (Meadows et al. 1972) had already emphasized that in pursuing current growth patterns humans face a problematic future:

> "If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next 100 years. The most probable result will be a rather sudden and uncontrolled declined in both population and industrial capacity" (Meadows et al. 1972).

As noted at the outset, resource consumption has accelerated significantly since 1972 and will likely continue to do so in the 2000s. According to an increasing number of studies we are already facing the limits of several critical resources such as food land, water, forests and fossil fuels:

Food land: "Most high quality agricultural land is already in production, and the environmental costs of converting remaining forest, grass land, and wetland habitats to cropland are well recognized… Much of the remaining soil is less productive and more fragile" (WRI 1998).

Water: "About one third of the world's population lives in countries that are experiencing moderate to high water stress… By 2025 as much as 2/3 of world population would be under stress conditions. Water shortages… may put global food supplies in jeopardy…" (Meadows et al. 2004).

Forests: "There has been a clear global trend toward a massive loss of forested areas. … the current trends are towards an acceleration of the loss of forested area, the loss of residual primary forests, and progressive reduction in the internal quality of residual forest stands… Much of the forest that remains is being progressively impoverished, and all is threatened" (World commission on forests and sustainable development 1999).

Fossil fuels: "Our analysis of the discovery and production of oil fields around the world suggests that within the next decade, the supply of conventional oil will be unable to keep up with demand… Global oil discovery peaked in the early 1960s and has been falling steadily ever since… there is only so much crude oil in the world, and the industry has found about 90 percent of it" (Campbell and Laherrere 1998 as cited from Meadows et al 2004).

Concerns for resource scarcity has been condemned and pushed aside mostly by mainstream economists who argue for continued growth of the human economy (Simon and Kahn 1984), for our capacity to find substitutes for scarce resources (Solow 1974; 1992); and for humanity's ability to stabilize any future ecological changes (Simon and Kahn 1984; Simon 1996). While it might be true that humanity has the potential to overcome various problems, people are slow to react to many ecological challenges because they do not perceive immediate negative feedback from them. We therefore remain unaware of the real state of the natural resources and systems we depend on, often because they are in distant parts of the world (Meadows et al. 2004). Globalization in its current form can be seen as a blinding mechanism (Goldsmith and Mander 2001), contributing to the distancing of necessary ecological feedback (Princen 1997; Conca 2002; Rees 2002a).

(2) *A full world approach* – Herman Daly (1991) coined the terms empty world and full world economics. He argued that humans have moved from living in a relatively empty world to a relatively full world. Daly's approach counters the main stream optimistic economic view. He argues that we must acknowledge increasing resource scarcity.

"The human economy has passed from an era in which human-made capital was the limiting factor in economic development to an era in which remaining natural capital has become the limiting factor." (Daly 1991:2)

> “Historically, in the ‘empty world’ economy, manmade capital was limited and natural capital superabundant. We have now, due to demographic and economic growth, entered the era of ‘full world’ economy, in which the roles are reversed. More and more it is remaining natural capital that now plays the role of limiting factor (Daly 1995:50)

Various studies have attempted to calculate the extent to which humans have appropriated supporting natural system services. These studies supply us with estimates of the extent to which our world is getting fuller. One such group of studies estimated current human consumption of terrestrial net primary products (HTNPP). These studies show an average appropriation of between 30% and 50% of the terrestrial net primary products (Vitousek et al. 1986; Vitousek et al. 1997; Rojstaczer et al. 2001; Imhoff et al. 2004). Imhoff et al. (2004:872) emphasize the potential for an increase of HTNPP as a result of increasing global population and per capita consumption, especially in the developing parts of the world.

According to the WWF (2006), about 64% of global terrestrial productive ecosystems are already being appropriated as part of humanity ‘ecological footprint’. Including the land that would be required to sequester CO_2 emissions creates a deficit of about 25% (WWF, 2006:29). The same study also indicates that from 1975-2003 the average per capita footprint increased by 14% while overall during the same period the per capita biocapacity decreased by 25%.

(3) *Ecological security* - Pirages and DeGeest (2004) and Pirages and Cousins (2005) dismiss the issue of resource scarcity and argue for an ecological security approach to the problems we are facing:

> “For the foreseeable future, resource scarcity is likely to be a relatively minor source of human suffering. Rather, infectious disease now is clearly the primary cause of premature human deaths and disabilities, followed by conflict among people, starvation, and various kinds of environmental disasters” (Pirages 2005:3).

Following Pirages (2005:4), ecological security is connected to humanity ability to sustain the equilibrium of the following:

1. Between human populations living at higher consumption levels and the ability of nature to provide resources and services.
2. Between human populations and pathogenic microorganisms.
3. Between human populations and those of other plant and animal species.
4. Among human populations.

Either human activity or natural change can disrupt these equilibriums. Unfortunately, the literature is full of evidence of just such disruptions. The recent MEA (2005:1) estimated that about 60% of the ecosystems studied all over the world (which are supposed to represent the overall world ecosystems) have been degraded or being use unsustainably.

For all of the reasons outlined, countries around the world have direct and indirect self interests in maintaining the ecosystems that support them. Their direct interests are in regions that provide ecological goods such as food and forest products. Their indirect interests are much broader and can be divided into practical and ethical interests. The practical include such interests as maintaining ecosystems services that might have indirect regional or global effects (e.g., climate mitigation). The ethical interest (which some will argue is also practical and part of the overall ecological security) can include the interest in unique ecosystems, or maintaining biodiversity for ethical reasons.

4.6 The place of an interregional approach to sustainability:

An interregional ecology approach as discussed here is still little appreciated and poorly documented. I believe four main factors can account for this under-appreciation: *the lack of negative feedback; a local versus global perspective; the uncritical acceptance of the dominant economic model; and the place of consumption in industrial societies*. Analysing these four themes contribute to understanding the current and potential future place of 'interregional ecology' approach to ecological change and sustainability.

<u>No alarm or action without negative feedback:</u> Negative feedback from supportive ecosystems can facilitate such an interregional ecology approach and its implementation into the local and international policy and planning. I believe that the lack of such feedback is a major reason for the low profile of the interregional approach in current discussions of drivers to local and global ecological changes.

The difference between traditional nomadic societies and our modern urban societies provides a good example. Nomadic societies were dependent on the ecosystems within which they lived. As long as those ecosystems could sustain them they remained in one place. When resources were exhausted or conditions changed they packed their belongings and moved on to the next place. Modern societies mostly live in permanent urban settlements. As emphasized, our dependence on ecosystems services has not been reduced but rather extended. The way we receive the resources we depend upon has changed. While in traditional societies only a small fraction of goods were obtained through trade, in modern societies biophysical needs are increasingly met with trade goods from distant ecosystems. If ecological conditions deteriorate, we do not move our homes but instead buyers shift to other suppliers who still have healthy ecosystems to supply society's demands.

There are many documented cases of ancient and more recent history that address degradation of ecological systems as a result of human activities (e.g., Ponting 1992; McNeill 2000; Diamond 2005). However, the degradation described in most studies predominantly impacts the local/regional society and leaves distant consumers largely untouched. An example is the collapse of the cod fishery in Canada's Atlantic region (Rogers 1995). This collapse had a significant social impact on the local population but in general the negative feedback that consumers in Canada or elsewhere, received was minor; consumers either got the same fish from another source or moved on to eating another kind of fish.

Various authors have pointed out that the increasing distance between producers and consumers eliminates much-needed negative feedback that might otherwise temper consumer demands (e.g., Rees 1994; Princen 1997; Conca 2001; Daly and Farley 2004). Spatial and social distance between production and consumption increases as commodity chains grow longer, more complex, and become more deeply transnational. In the absence of negative feedback, neither governments nor private consumers can take the degradation of their supportive ecosystems into account. Consumers lack the information and incentive to behave in a more sustainable fashion even if they are disposed to do so (Conca 2001).

Although, or perhaps because, we are living in a globalizing world, we cannot see most of the negative ecological consequences of our activities. It is probably a basic human characteristic that we mostly care for what appears to immediately affect us (e.g., a polluted river passing through town). The more distant impacts are and the less we feel affected by them, the less we care – "out of sight, out of mind" or as it is said in the Hebrew language, "Far from the eye, far from the heart".

Popular attitudes and international law have not caught up to global reality: In general, the international community still sees most 'environmental' problems as relatively small-scale (pollution) problems that are mainly of concern to local or, at best, national governments (MacNiell et al., 1991; Speth, 2004; Mason 2005). Traditionally, governments have responsibility for only those environmental issues that unfold within their own boundaries. Thus, even as global change accelerates, the policy focus of most countries and international organizations is at the local/national level (UN 1992; Vitalis 2003; Clapp and Dauvergne 2005). The situation is complicated by the fact that national sovereignty remains a core principle of international politics—every country has the right to exploit its domestic natural resources as long as that exploitation does not *directly* impact other nations (Litfin 1998; UN 1973; 1992).

The issue of national sovereignty can explain the place of the three strands of interregional ecology discussed above: the conventional production strand, the local production and consumption strand and the trade flow strand. It emphasizes why the former is becoming more legitimate in international policy (Litfin 1998; Mason 2005) and why the local and trade flow strands remain subsumed under traditional rights of national sovereignty. Cross-boundary pollution is considered to undermine other nations' sovereignty while resource exploitation within national boundaries is considered legitimate. This legitimacy is maintained in spite of the facts that: the local exploitation might supply the demands of another country; the exploitation might degrade the local ecosystems and their ability to provide services; that degradation might indirectly impact other nations; and that exploitation might benefit a small group of people and harm much larger populations.

Focusing on the local scale makes sense as this is the level at which we are probably most efficient at making decisions, implementing, and enforcing them (Daly and Cobb 1989). Since the first international discussions on global environmental problems, responsibility for action has been assigned at the national level. This tactic assumes that if every country follows a certain path the result will be positive for everyone (UN 1973; 1992). However, as we largely do not receive negative feedback from our activities, our local actions are not likely to reflect awareness of our dependence on others, nor the impact we may have on them.

Another dimension of the problem is a global one. Issues such as ozone depletion and climate change have been discussed and international agreements have been signed. But even here the focus is an obligation for each country to reduce/change impacts within its political boundaries; in certain cases to prevent impact on the regional or global environment. The well known Kyoto Accord, for example, commits each country to reduce its own emissions. Limited attention is paid to the emissions a country indirectly emits while importing from another country. That perspective was raised in discussions by the International Committee on Climate Change and is part of several recent academic studies but it has not been implemented yet. The idea is for example that part of the CO_2 China produces might be attributed to U.S. consumption and vice versa. Another representative example would be the Canada - Costa Rica Agreement on Environmental Cooperation (part of the free trade agreement between the countries), which discusses some of the ecological problems each country faces but does not address the role, self interest and responsibility each of the sides has on the state of the ecosystems within the other's political boundaries (Environment Canada 2002).

As ecological degradation at the global scale continues, taking a single dimension perspective that monitors and reports ecological problems at one particular level is not enough. An interregional ecology approach can relate some of the degradation processes in a certain country to demands in another. While it is true that there are many drivers for degradation, taking an interregional approach can certainly highlight those drivers which are connected to production for export. If the path we are taking is toward a globalized world, we should understand and be able to see the ecological dependence of one region on another. Without this understanding we are blind to many of the ecological consequences of our lifestyle choices.

<u>The current mainstream economics perspective:</u> I argue that the nature of the prevailing economics paradigm is a major reason for the lack of attention to such an interregional ecology approach. The lack of negative feedback and local perspectives are a result of, and at the same time provide legitimacy for, current economic thinking. The focus of economic development is mostly on the local level. Many environmental issues first appear as small-scale pollution problems that are mainly of concern to local governments (MacNiell et al. 1991; Speth 2004). Pollution problems are regarded as "externalities" by economists. Since the 1960s some environmental economists have proposed instruments to internalize the pollution consequences of economic activities. However, resource depletion driven by material consumption is almost never discussed. Economists are generally confident that the free market system will signal a scarcity of resources by increasing costs which will lead to reduced consumption and more efficient or different modes of production. Moreover, many economists dismiss concern for resource scarcity on grounds that human ingenuity can create an unending supply of substitutes for depleted biophysical resources (e.g., Simon 1981; Beckerman 1995). Some assert that there are no limits to potential harvests (Solow 1972; Summers 1991; Simon 1999).

By contrast, the relatively new field of ecological economics challenges many mainstream economic assumptions of unconstrained growth (e.g., Costanza and Daly 1987; Costanza et al. 1991; Daly 1991; 2001; Rees 1992; 1995; Norgaard 2001). As world population and resource extraction increase, our ability to substitute one resource with another is increasingly limited, and the impact of extracting the required resources begs the question: Can we continue to increase material outputs without major penalty? (Rees 1992; 1995; Norgaard 2001; Daly and Farley 2004:112; Robinson 2004). The interregional perspective on human ecology supports ecological economics analyses. It emphasizes that while globalization and trade can bring short term material benefits around the world, it also accelerates resource depletion and ecosystem degradation.

<u>Consumption versus production perspectives:</u> It has been widely acknowledged that, for sustainability, changes in global production and consumption patterns are required. For example: Principle 8 of the Rio Declaration on Environment and Development (1992) emphasizes the need to "reduce and eliminate unsustainable patterns of *production* and *consumption*". Chapter 4 of the UN Agenda 21 explicitly identifies unsustainable *production* and *consumption patterns* as "the major cause of the continued deterioration of the global environment" (UN 1992: 4.3). The Johannesburg Summit (WSSD 2002) recommended development of a ten year framework of regional and national initiatives on sustainable consumption and production. The United Nations Commission on Sustainable Development (1995) defined both sustainable production and consumption:

> "Sustainable production involves the creation of goods and services using processes and systems that are non-polluting; conserving energy and natural resources; economically efficient; safe and healthful for workers, communities and consumers; and socially and creatively rewarding for all working people. Sustainable consumption entails the use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life-cycle so as not to jeopardize the needs of future generations."

Adam Smith, one of the fathers of current neo-classical economics, wrote in his famous manuscript 'The Wealth of Nations' (1776): "Consumption is the sole end and purpose of all production…" (as cited from Boulding 1945). Although Smith was not dealing with issues of ecological sustainability, and the context of his writing was different, he emphasized the need to look at the role consumer demand plays in production. Boulding (1945:1) argued that despite the focus on consumption by Smith and several other economists, the development of economic thought has shifted towards production, distribution, and exchange. Production and consumption approaches to sustainability are a result of different world views and different kinds of understanding and interpretations of the sustainability issue. As will be suggested later in this dissertation, both contribute to the discussion of interregional ecology and, I believe, can contribute to sustainability.

Although consumption has been identified as a major cause of environmental problems and a change of consumption patterns recognized as a potential key to sustainability, it is most often *production* processes and patterns that are addressed in sustainability literature (Princen 1999; Cohen and Murphy 2001; Princen et al. 2002; Tucker 2002). It is widely accepted that the producer is the polluter, and so if anyone should carry responsibility for pollution or any other damage it should be the producer. Attempts to increase consumer responsibility and to alter consumption patterns have not yet succeeded (Barber 2003).

The focus of the production approach to sustainability is mitigation of ecological problems associated with material economic production. A key concept of this approach, which has found its way into many sustainability related policies, is *efficiency*. The simple logic is that more efficient means of production employing new technologies can reduce throughput and therefore the negative ecological impacts of production (Von Weizsacker et al. 1997 ; Hawken et al. 1999). This approach to sustainable development fits well within mainstream economic thinking that views economic growth and the function of the market as the main mechanisms for achieving sustainability. Nonetheless, it acknowledges some biophysical constraints and attempts to reconcile economic growth with ecological limits. Ever since the beginning of the 1990s, researchers have suggested that we can increase our industrial efficiency by a factor of four and even ten (e.g., Von Weizsacker et al. 1997; Schmidt-Bleek 1997).

Unlike the production approach which relies on efficiency as a means to achieving sustainability, a consumption approach is linked to the idea of sufficiency (Princen 2003; 2005). Proponents of sufficiency, argue that efficiency is useful, but will not lead to ecological sustainability. Instead, it leads to increased consumption. Rees (2005; as cited from Herring 2006:13) points out that improvement in the efficiency of resource use, such as with computers, leads to a decline in the price of products, a mass market and hence a large global consumption of resources. The same argument is made for the case of the automobile (Princen 1997): while it is true that the fuel efficiency (and emissions) per km have reduced within the last few decades, overall fuel consumption have increased as more people use more cars to travel much farther distances.

The sufficiency argument aligns with the biophysical approach to sustainability in acknowledgement of the limits of the earth's ecosystems carrying capacity and in recognition of the problematic nature of current human lifestyles. It challenges those who live in the wealthier parts of the world to consider the negative ecological impacts of their consumption (e.g. Durning 1992; Princen 1999; 2003; 2005; Princen et al. 2002; Cohen and Murphy 2001; Rees and Westra 2003; Myers and Kent 2004; Dauvergne 2005b). Unlike the efficiency approach, a sufficiency perspective focuses on social change much more than it does on technical change.

Finally I believe that the reasons for the place of interregional ecology in the sustainability discussion discussed above are critical to understanding of the place of consumption approach: (I) The lack of negative feedback - As long as there is no negative feedback there is no reason to change our consumption patterns. If we can always replace the sources and find substitutes, and technology can reduce some of the negative impacts of production, then we can continue to increase material consumption. (II) The local perspective - As sustainability is addressed mostly at the local level it makes sense to reduce the pollution impacts of production at that level. We see local pollution as the responsibility of the producer to be dealt with in the producer region. Even if the producers are far away, rich consumers are blind to the impacts or content to ignore them. (III) The current economic perspective – Proponents of current mainstream economics characterizing consumption as essential to human well-being, they are primarily focused on increasing income and consumption. On the other hand, they are concerned with making production more efficient because efficiency can reduce material and energy costs and seem to decrease externalities while actually raising wages and lowering prices, this further increasing consumption.

Chapter V - Modeling an Interregional Ecology Approach to Sustainability

As appear from previous chapters, four key words capture the lesson of the interregional approach to sustainability: *Interdependence, impact, self-interest* and *responsibility*. In the increasingly interconnected world of today, any region 'A' can easily become *dependent* on resources provided by distant ecosystems in regions 'B' and 'C' far beyond its domestic boundaries and 'B' and 'C' may, in turn, become dependent on products of 'A'. Production of consumption goods anywhere has the potential to *degrade* the ecosystems and natural processes that directly and indirectly provide those goods and services. This raises questions regarding *interest* and *responsibility.* Humans are usually motivated by self-interest and tend to ignore negative effects of their selfish actions if they fall somewhere else or on someone else (Rees 2007). However, in an ecologically full world at the limits (e.g., Daly 1991; Meadows et al. 2004) ecological changes anywhere on Earth may have direct and indirect consequences for people everywhere. In the present context, both producers and consumers have an interest in maintaining the productive integrity of the ecosystems that provide an income to the former and valued goods and services to the latter. Therefore, should not both producers and consumers be held mutually responsible for the deleterious impacts of the production-consumption process?

After laying down the theoretical basis of such an approach to sustainability the next step would be to model these kinds of connections and to quantify interregional relationships. In this chapter I focus on creating the model; a model that will be empirically examined in the following chapters.

5.1 Background:

As society has become more aware of the implications of global ecological change, the need better to understand the biophysical connections between human activities and global trends has been widely acknowledged (e.g. WCED 1987; EUROSTAT 2001a; UN 2001; MEA 2003; 2005). This understanding has accelerated the development of measurement tools emphasizing industrial metabolism (Fischer–Kowalski 1998) and the physical dimensions of the human economy (Ayres 1998; Daniels and Moore 2002). Tools such as: Material Flow Analysis (MFA); Physical Input Output Tables (PIOT); Life Cycle Assessment (LCA); Ecological Footprint Analysis (EFA); Environmental Space; and Material Intensity Per Unit Service (MIPS) are representative of the many methods that quantify the physical dimensions of human activities and enhance understanding of human dependence on the natural world (Ayres 1998; Daniels and Moore 2002). Separately and together these tools contribute a great deal to the interregional ecology approach developed here. It is both, what each tool presents, and what is missing that I believe contributes to the approach studied here.

These measurement tools have several common properties which play an important role in developing an interregional approach to sustainability: First, they perceive the connections between human activity and the natural environment in terms of both resources (i.e., material and energy inputs) and wastes. Second, these tools reflect a "whole process" approach to either production or consumption. They measure not only economically relevant flows but also identify indirect effects and potential impacts (Daniels and Moore 2002). Third, each method can be implemented at different spatial scales (local to global) or at the product, sectoral or industry level (e.g., Birgenzu and Schutz 2001; Halberg and Weidema 2004; Kissinger *et al*. 2007). Individually and even collectively, however, these methods are deficient in important ways. Though some of the tools listed above imply systems complexity, they focus relatively narrowly on particular places or products and thus mostly overlook two key aspects of sustainability: 1) the geographical source(s) of trade goods and 2) the ecological consequences of production-consumption, particularly at the point of origin.

I focus here on four popular tools to show how they might be modified to include ecological impacts at both ends of the production-consumption stream: Material Flow Analysis (MFA), Life Cycle Assessment (LCA), Physical Inputs Outputs Tables (PIOT), and Ecological Footprint Analysis (EFA). In the following paragraphs I first describe each tool, highlighting some of its advantages and shortcomings. I then suggest how each tool can contribute to the interregional ecology approach presented here. I also present here the Commodity Chain analysis (CCA). This analytical approach, developed by sociologists, though dealing with issues other than ecological sustainability is relevant as part of the background for modeling interregional connections.

5.1.1 Material Flows Analysis (MFA)

MFA involves a systematic assessment of the stocks and flows of materials within any macro system – city, region, country – defined in space and time (EUROSTAT 2001a; National Research Council 2004). The purpose is to provide complete and consistent information about all movement, consumption and remaining reserves of energy and material within a relevant system. Analyzing material flows associated with a certain activity facilitates early recognition of problems such as future environmental load and resource depletion (Brunner and Rechberger 2004:4; National Research Council 2004: 17). MFA shows the connections between the economic subsystem and the ecosphere; resources are extracted from nature as inputs to the economy, transformed into products, and ultimately returned to 'the environment' as waste (Fischer-Kowalski and Huttler 1999; Hinterberger et al. 2003).

MFA has emerged in various fields including medicine, chemistry, economics, engineering, life sciences, natural resource and waste management, and other aspects of environmental management (Brunner and Rechberger 2004:13). MFA has been conducted at scales ranging from the local to the international (e.g., Wolman 1965; Duvigneaud and Denayeyer De Smet 1975; Girardet 1999; Adriaanse et al. 1997; Matthews et al. 2000; Bringezu and Schutz 2001).

MFA has several positive qualities as a measure of environmental performance and sustainability: first, it attempts to account for *all* inputs of material and energy resources, and all outputs of waste. Second, it consolidates a large amount of data on the materials required for particular economic activities. Third, it serves as part of the foundation for other sustainability measurement tools such as Life Cycle Assessment, and Ecological Footprint Analysis. MFA also has significant shortcomings:

(I) The lack of connection to ecological degradation - Although MFA aggregates the inputs and outputs of economic activities or places, the links between MFA indicators and impacts on the environments are weak (Hinterberger et al. 2003:11). While revealing connections between the economy and nature, the method does not identify the impacts of material flows on exploited ecosystems. Finally, MFA uses the same metric in accounting for both self-producing and non-renewable resources, making no functional distinction between a tonne of fish and a tonne of coal.

(II) The failure to specify sources - MFA compiles inventories of materials involved in a production or consumption activity, but it usually does not identify the geographic sources of these materials. Some MFA researchers make a distinction between domestic material consumption and total material consumption, but do not explore the origins of corresponding inputs (Hinterberger et al. 2003:7). This omission is important because the extraction or harvesting of resources from different sources involves different methods/technologies and thus produces different ecological consequences.

5.1.2 Life Cycle Assessment (LCA)

LCA acknowledges that production and consumption contribute to adverse ecological effects, and that these effects can occur at all stages in the life cycle of a product. Indeed LCA has been defined as the "Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO, 1997). As Hinterberger et al. (2003) point out, there are many similarities between LCA and MFA—both account for material inputs and outputs – but while MFA usually focuses on larger systems, LCA focuses on specific sectors or products, tracing their impacts from cradle to grave. In addition, while MFA accounts for only material and energy use, LCA deals with both consumption and environmental impacts (mostly pollution). Finally, while some MFAs make the distinction between direct and indirect material and energy flows, most ignore the 'hidden' flows required for extraction or production of the primary flows in distant locales. LCA attempts to capture these latter flows for the specific products being assessed. LCA has become an important tool as industry attempts to become more responsive to sustainable development requirements, including strict environmental regulations in certain countries, and more efficient in the face of rising energy costs (Vizcarra et al. 1999; Halberg and Weidema 2004; Berg and Lindholm 2005).

LCA has several merits as an environmental performance and sustainability measurement tool. First, it acknowledges that any product involves use of diverse materials and energy sources. Second, LCA accounts for (some of) the environmental impacts generated in a product's life cycle. It thus identifies most potential points of intervention for improved material and energy efficiency and reduced pollution loading in the product's life cycle. Its shortcomings include: (I) Loose connections to ecological degradation - While LCA does account for several potential environmental hazards, such as air and water pollution, it generally does not extend to broader issues such as landscape degradation, ecosystemic change, and source depletion.

(II) Failure to identify specific sources of materials - Although a product's life cycle affects a variety of locations, most researchers present the impacts as if occurring at a single point or in "virtual space"; neither processes nor ecological consequences are tied to particular locations (Kollner 2003). Only recently have some LCA researchers, referring to LCA in the context of global trade, begun to ask questions about the scale and sustainability of human activity (e.g., Schlich and Fleissner 2005; Jungbluth and Demmeler 2005).

(III) A product versus a whole economy approach – Most LCA studies focus on specific sectors or products, ignoring the consequences of larger scale economic activities. While it is important to study the life cycle and the incremental impacts of specific products, LCA presently ignores the relative contributions of products to the macro-scale ecological changes that result from aggregate economic activity.

5.1.3 Physical Input Output Tables (PIOT)

Input Output (IO) analysis is a top-down economic method that uses data from sectoral monetary transactions to account for the complex interdependencies of sectors in modern economies (Munksgaard et al. 2005). The Monetary Input-Output method (MIOT) was introduced by Leontief (1936). MIOT has played an important role in macro economic policy analysis and forms the basis of national economic accounting systems (Hubacek and Giljum 2003). Since the late 1960s, Input-Output methods have also been used to describe various connections between economic activities and the environment, again mostly in monetary terms. Material parameters were added to IO analysis during the 1990s with the development of Physical Input Output analysis (PIOT). PIOT extended conventional MIOT by accounting for actual quantities of resources and wastes. That is, like MFA, PIOT measures physical flows within the economic system, and between the economy and the natural environment. PIOT tracks natural resources from their entry into the economy, throughout their processing and use as commodities, to their return to the natural environment as waste (Daniels and Moore 2002). The goal is to characterize the physical structure of the economy and to provide scientists and policy makers with a tool for a comprehensive analysis of economy-environment relationships (Hubacek and Giljum 2003).

A major strength of PIOT is that input-output tables display the total input requirements for each unit of final demand. PIOT accounts for both the direct and indirect inputs/outputs of production within specific economics sectors and links the latter materially to other sectors of the economy. Uniquely, PIOT can be integrated with MIOT, thus combining physical and monetary flows in the same tool. However, PIOT suffers from the same shortcomings as the other tools discussed above. Most significantly:

(I) Failure to connect to ecological degradation - Although PIOT accounts for the total material flows associated with economic activities, it does not link these to specific identifiable impacts within or beyond the specific study area.

(II) Failure to specify sources of the materials - PIOT provides an accounting for materials required for the economic activities within a particular region (usually a nation). However, it does not trace these materials to source.

5.1.4 Ecological Footprint Analysis (EFA)

More than a decade ago, Rees (1992) introduced Ecological Footprint Analysis (EFA), a quantitative tool that uses data on energy and material consumption and waste production to estimate the biophysical 'load' that any specified human population imposes on its supportive ecosystems (Rees & Wackernagel 1994; Rees 1996; Wackernagel and Rees 1996). While the three methods discussed above generate data on material flows and, in some cases, their connection to ecological impacts, the EFA is unique in that it associates the material demands of the human economy to the corresponding terrestrial and aquatic ecosystem area 'appropriated' to fulfill that demand. Thus, the ecological footprint of a specified population is the total area of land and water ecosystems required to produce the resources that the population consumes and to assimilate (some of) the wastes that the population generates, wherever on earth the lands/waters are located (Rees 2001). EFA tables quantify the energy and material requirements of consumption and compute the ecosystem area upon which the consuming population is dependent for those resources. A population's EFA (demand) can then be compared to readily available supply—i.e., the study population's domestic bio-capacity (its productive land/water area). EFA thus provides a way to determine whether study populations are living within their domestic ecological means, or have 'overshot,' local/national carrying capacities. In the case of overshoot, EFA also estimates the ecological burden that the study population imposes on other countries and the global commons (Rees 2002c, 2006). Wackernagel *et. al* (1999) and now the WWF (2006) regularly use EFA to compare national per capita eco-footprints with domestic biocapacities, both in term of standardized global hectares. Aggregate EFA analysis reveals that the world as a whole is in overshoot by at least 20% (WWF 2006).

EFA's major advantage lies in the fact that it makes explicit connections between human consumption habits, product by product and several types of appropriated ecosystem area. This enhances its strength as an ecological performance and sustainability measurement tool. EFA reveals the gap (positive or negative) between demand in multiple resource categories and the local supply of biocapacity. By so quantifying the study regions eco-deficit (Rees 1996) it can be used to highlight a study population's trade-based dependence on different types of distant ecosystems and thus, the vulnerability of that population to the effects of both local and global ecosystems changes.

EFA also has shortcomings:

(I) Failure to identify the specific sources of materials **-** Though EFA estimated eco-deficit as an indicator of inter-regional dependence, typical applications do not 'locate' the ecosystem areas making up either the total EF or the deficit component. Standard population EFAs do not show how specifically the population EF is partitioned between local and off-shore support areas.

(II) The lack of connection to ecological change – As noted, EFA estimates the total ecosystem area required to support a given study population wherever on earth those ecosystems are located. However, like the other methods examined, EFA does not reveal place-specific cause and effect relationships between the study population's consumption and associated negative ecological impacts (pollution, erosion, stock depletion, etc.).

5.2 Towards an interregional ecology model

As implied above, and discussed in details in previous chapters, local sustainability clearly involves much more than sustaining local ecosystems. The physical impacts associated with the material flows required to support any specified regional population or economy occur both at the point of consumption and in the case of impacts associated with both earlier and later stages of the product's life cycle, at great distance from consumption. Contemporary ecological footprints are increasingly scattered all over the world. While all the tools discussed herein imply an interregional approach, they generally don't explicitly exploit this potential. As currently structured, these methods lack geographic specificity and fail to connect materials extraction processes and consumption to specific ecological consequences of economic activity. In short, they do not yet tell us where our eco-footprints fall. Where do the materials we consume come from and what are the distant ecological consequences of that consumption?

On top of the above sustainability assessment tools another approach that need to be discussed here and is relevant as a background for modeling interregional connections is Commodity Chain analysis (CCA).

Commodity chain analysis:

Commodity Chain Analysis (CCA) is an analytical approach developed within the last two decades (e.g. Hopkins and Wallerstein 1986; Gereffi and Korzeniewicz 1994). CCA studies acknowledge that in a global economy we need to study the social, political and economic implications along the ‘commodity chain’. While CCA studies do not document the kind of consumption and ecological change linkages emphasized in this dissertation, and mostly do not discuss sustainability issues, their global and interregional perspective supports a conceptual background for modeling interregional ecological connections.

CCA has its basis in the theoretical political economy of ‘World Systems’ focuses on the role of global power relations and supply chain structure. Hopkins and Wallerstein (1986:159) describe a commodity chain as a network of labor and production processes whose end result is a finished commodity. Gereffi et al. (1994:2) see interorganizational networks of commodities linking households, enterprises and states to one another within the world economy. Specific processes within a commodity chain are represented as ‘nodes’ (the locations of raw material extraction and production, processing, distribution centres, and final consumption locations) linked together in global networks.

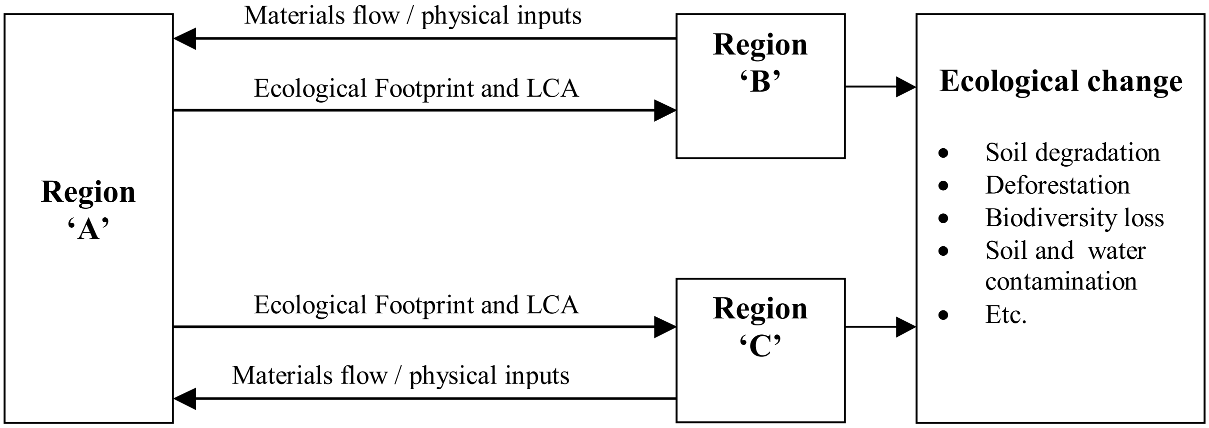
From the perspective taken in this dissertation two major shortcomings of the CCA are:
(I) The lack of connections to ecological change and sustainability – While CCA studies focus on social, political and economical implications of the commodity chain they almost entirely ignore any connections to pressure on ecological systems along the commodity chain.
(II) The focus on specific commodity – Most CCA studies focus on a specific commodity or its interaction with another one, ignoring the consequences of larger scale economic activities. While that approach allows to understand and study in details the implication of the specific commodity along the chain it doesn’t cover the macro-scale issues.

Researchers working on each of the above methods acknowledge the need to expand the focus of each tool so it will address some of the issues raised here. Moriguchi et al. (2003), and Schutz et al. (2004), discuss the material flows of Japan and the EU respectively, and the increasing dependence of these study areas on overseas sources for materials; Owens (1997) discusses the potential as well as the limitations of life cycle studies to move from inventory stage, which summarizes the materials and energy involved, to impact assessment, which attempts to examine environmental issues. He suggests the use of LCA together with other techniques and sources of information such as environmental monitoring or ecological and human health risk assessments; Goedkoop et al. (1998) developed an LCA model that captures some of the connections between resource use, land use and emissions to damage to resources, ecosystems and human health; Udo de haes et al. (1999a) identified what they see as the best available practice concerning impact categories and indicators in LCIA. Their model overviews the relationships between several environmental interventions (e.g., Land use, BOD, CO_2), Midpoints (e.g., loss of habitat, oxygen depletion, climate change), and endpoints (e.g., biodiversity loss, loss of fish stock, damage to human). They also acknowledge the need to take into account the spatial differences between regions and the need to have data which reflects the specific region characteristic (Udo de Haes et al. 1999b: 72); Kollner (2003) develop a LCA model that traces some of the correlations between land use and biodiversity loss; Wurtenberger et al. (2006) studied Switzerland's "grain virtual land use" and looked for connections between grain imports and ecological pressure on supporting lands by combining some of the discussed tools with ecological and social indicators; Ghertner and Fripp (2007) use LCA to capture some environmental pressures U.S. trade imposes on that country's trade partners around the world; Erb (2003) extended "traditional" EF analyses in a study of Austria, by determining, continent by continent, the total land base on which that country depends and Warren-Rhodes and Koenig (2001) quantified Hong Kong's EF and the part of that footprint on China. In a recent study I (Kissinger and Haim 2007) disaggregated the EF of an Israeli town, asking how much of the urban supporting lands are local and how much are located overseas? Finally, recently the International Institute for sustainable development (IISD 2006) has identified the need to expand current Commodity Chain Analysis (CCA) so that it will include sustainability issues. They highlight the need to develop a Global Commodity Chain Sustainability Analysis (GCCSA). However, they acknowledge the need to use EFA and LCA in order to document the commodity chain linkages to the ecological consequences and sustainability.

As matters stand, no single method adequately links product production / consumption to ecological change. Analysts are usually forced to rely on state of environment reports and other environmental studies – EIA, land use reports, etc., – to infer causal links between their material flows or LC analyses and ecological degradation. These independent environmental reports have different purposes but, in the interim, each can contribute to documenting the relationship between resource demand, product consumption and ecological change. To summarize and understand fully the ecologically significant relationships among interdependent regions requires a combination of key features of the tools discussed above and disaggregation of the results on the finest possible spatial scale. Ideally we should be able to specify in time and place the origin of resources consumed and the ecological impacts of resource exploitation/consumption at both ends of the economic transformation process.

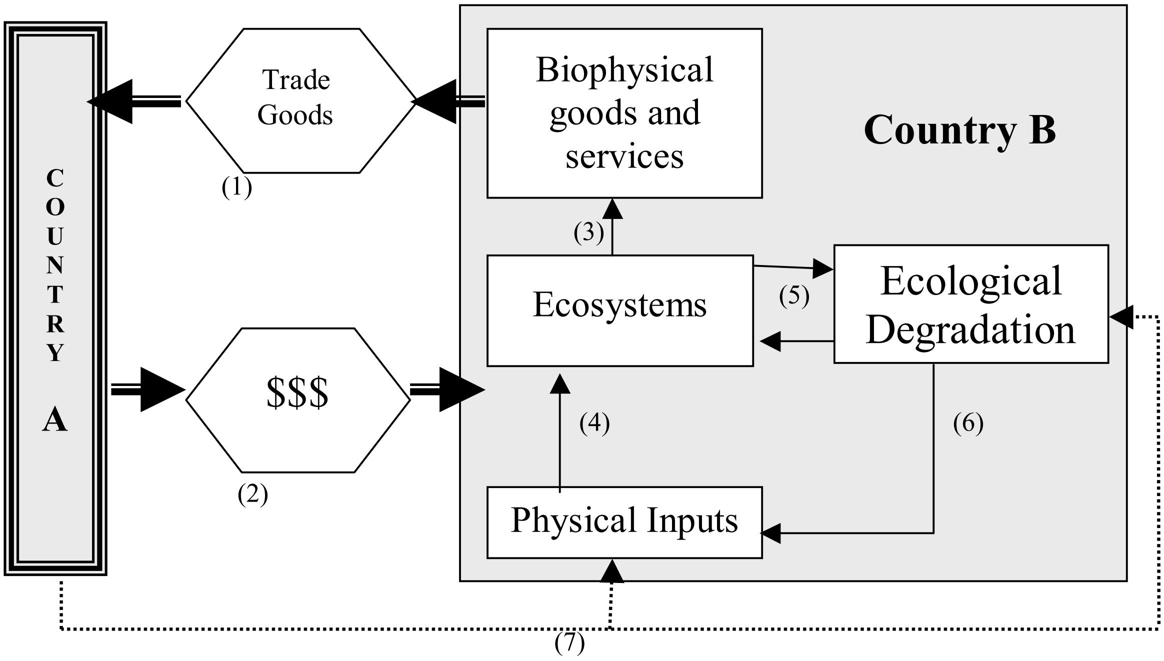
As shown in the following Figure, resource/waste flows and product life cycles do not take place solely at the point of consumption (region 'A'); significant parts of these processes and their effects may occur within supporting (exporting) regions ('B' and 'C'). The flow of materials from Region 'B' and 'C' to region 'A' underscores that a corresponding portion of region 'A's eco-footprint extends into regions 'B' and 'C'. Thus, some local ecological changes (e.g., landscape degradation, resource depletion, pollution) occurring in these exporting regions can be attributed to consumption by the residents of region 'A'. In a globalizing world most regions are involved in trade. Therefore any region may be both an importer (i.e. region 'A') and an exporter (i.e., region 'B' or 'C') of both the same and different commodities.

Figure 1: Disaggregating consumption to show material sources and ecological consequences



Building on the above, I advance the following model (figure 2). (1) Country 'A' imports from country 'B' (i.e. traded commodities flow from country 'B' to country 'A'). (2) Money payments flow from consumers in country 'A' to country 'B'. (3) Country 'B's ecosystems naturally generate biophysical goods and services. (4) However, country 'B' uses physical inputs such as mechanization, irrigation, pesticides and fertilizers to increase the production of these goods. (5) Unfortunately, these material inputs generally accelerate **ecological degradation** which ‘feeds back,’ reducing eco-systems productivity and sustainability. (6) This in turn, feeds back on resource managers, stimulating increased use of fertilizer, irrigation, etc. This maintains productivity but also further accelerates degradation. The deterioration of export-oriented ecosystems can reduce global sustainability as these systems lose their ability to support both the importing and exporting countries. (7) Thus, the more country ‘A’ imports from country ‘B’ the more it becomes **dependent** not only on the traded goods, but also on the sustainability of country ‘B’s ecosystems and on the material inputs used to enhance production. In short, the citizens of both countries have an **interest** in conserving the ecosystems of country ‘B’. Appropriate legal/institutional and economic policy measures should be implemented to enable/require ‘A’ to assume its share of **responsibility** for maintaining supporting ecosystems in country ‘B’.

Figure ‘2’: The Interregional Ecology model



Interest and Responsibility

Chapter VI - Research methods

Chapters II to V present the context and theory behind my interregional approach to ecological sustainability. In this chapter I present the method, a calculation procedure that I later apply to a number of empirical cases. The chapter is divided into two sections: the first sets the boundaries of the dissertation, introduces sample applications, describes structure of the research and highlights some technical and practical limitations. The second section provides a detailed discussion of the methods, assumptions and scope of each of the empirical studies.

6.1 Overview of research procedure

6.1.1 The dissertation as part of the bigger picture

This research documents a small part of a complex worldwide network of interregional relationships. I trace and document some of the material flows between selected exporting (producer) countries and selected importing (consuming) countries. In 2008 almost any country engages in international trade and therefore could serve as a producer or consumer case studies.

Natural resources are commonly divided into renewable and non-renewable resources. The extraction (and consumption) of both kinds puts pressure on eco-systems. This dissertation focuses on renewable resources, in particular on a large group of agriculture products. I attempted to account for different physical inputs (land, water, chemicals and energy) involved in growing / producing the commodities studied, and links their use to documented ecological change in producer regions. However, land is the input explored in greatest detail; other inputs are only partially represented due to lack of data and the need to limit the study's scope.

While the study examines several major export products and their connections to processes of ecological change in considerable detail, it necessarily remains illustrative. It describes only some of the direct and indirect pressures on ecosystems resulting from material exchange.

6.1.2 Research case studies

I focused on three countries to illustrate and elaborate the methods proposed herein: the United States of America (U.S.), Costa Rica and Canada. Other regions of the world are necessarily referenced, both as the source of products and as export destinations. While the method and calculations developed here could be used to characterize relations between almost any countries, I chose the cases examined here for the following reasons:

Level of trade engagement - As the overall purpose is to illustrate the importance of interregional material linkages between selected countries in driving ecological change, it is important that the cases examined be countries that are significantly engaged in trade with other countries, preferably with each other.

Data availability – The availability of data is crucial to document the interregional ecological connections. This study involves a large data sets including: *trade data* - information on the flow of resources commodities from one producing country to consumers in another; *production data* – data on inputs to the growing or producing of different commodities in the sample countries; *ecological data* – information connecting particular resources or commodities to ecological impacts.

Most sources document trade flows in monetary terms ignoring physical measures such as mass and volume. Unfortunately too, the data available on ecological issues is limited. In short, some countries, commodities and ecological related issues are documented better than others.

Each of the cases selected for analysis has advantages and disadvantages. There is a good chance that other cases would illustrate, for example, higher levels of dependence or greater ecological changes. However, my intent was not to choose the most trade dependent country or the most ecologically affected country but rather to select countries that would illustrate a tool capable of empirically testing some aspects of the theoretical approach developed in previous chapters. Global trade relations are complex and trade flows are multi-directional. The case study nations selected for this research all trade with one another as well as with numerous other nations, importing and exporting a wide range of renewable resources. Consequently, the United States, for example, depends on imports from Canada and Costa Rica and as argued here, has some responsibility for ecosystem degradation in both of those countries. At the same time, Canada and Costa Rica import renewable resources from the U.S. and thus can be viewed as partly responsible for ecological changes there. This project is necessarily limited to investigating only a fraction of the interregional connections among these countries.

6.1.2.1 The United States - the major import case study

The first case examined is the United States of America (U.S.). I chose the U.S. for several reasons: (I) the country has a broad network of trading partners. It exports goods and materials to many countries and it imports a large variety of raw materials and manufactured products from others (WTO 2006). (II) The U.S. monitors its trade relations with countries around the world so that good data are available[1] (e.g., USDA 2007; USDOC 2007). (III) The U.S. is the world's largest economy, and has high per capita consumption levels when compared to global or even developed country averages. While the U.S. still produce most of its renewable resources commodities within its own territory the overall imports of renewable resources are increasing.

6.1.2.2 Costa Rica – export case study

Several factors also recommend Costa Rica as a case for study: (I) The country is heavily engaged in trade with the rest of the world and foremost with North America. (II) Costa Rica is economically dependent on cash-crop exports, and has converted large portions of its land ecosystems for agriculture. (III) The significant change in its ecological integrity (i.e., mostly deforestation and soil degradation) in recent decades and (IV) the relatively large amount of literature and data available on Costa Rican ecological systems and degradation processes. To make explicit connections between consumption in one region and ecological change in another I selected several of Costa Rica's export products - bananas, coffee, and beef - and studied the linkages between their production and ecological change. **Bananas, coffee and beef** account for a significant proportion of Costa Rica's agricultural production and large quantities of each are exported annually.

6.1.2.3 Canada – export case study

I chose Canada for study because: (I) while all wealthy countries are engaged in international trade, many export only a small part of their total production. Canada, on the other hand is a physically vast country with a relatively small population. Therefore, a large proportion of its production of agricultural products, forest products and minerals is devoted to export in effect to satisfy the ecological deficits of importing countries. (II) Various production activities, some of which are predominantly for export, have resulted in deterioration of major supporting ecosystems in Canada. (III) Relative to many other countries, and especially when compared to poorer countries, Canada provides a high level of data transparency. For present purposes I focus on the Canadian Prairie provinces where a significant portion of Canadian agriculture (mostly grain, oil seed, legumes and livestock) takes place and from which large quantities are exported.

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[1] Other countries do it as well, but mostly publish it in value terms.

6.1.3 Time scale – consumption in a particular year or throughout time

What is the most appropriate time scale for this research? Ought the research to focus on a particular year? or should it follow a process for several years or even decades? The specific year approach would create a snapshot of the level of consumption and trade at a particular time only. As ecological change (e.g., deforestation, soil degradation, water contamination, desertification and so on) is generally not the consequence of single year pressures but rather of pressures over a longer period, the multi-year approach is better if we wish to connect trade flows to ecological degradation processes. The disadvantage of this approach is the amount of data necessary, and the fact that data for certain years does not exist. In the main, I take a multi-year approach; I follow most production, trade flows, and ecological changes for a ten year period starting from the mid 1990's until 2004-2005. That period was chosen mainly for reasons of data availability. For some product and region ecosystem connections I was able to extend the documented time to the late 1980's and for certain products several decades before.

6.1.4 Different dimensions of interregional ecology

I analyzed three dimensions of interregional relations: import relations; export relations; and specific region and product relations. Each dimension on its own, while related to the others, contributes a piece to the puzzle of interregional ecology. Together they provide a relatively comprehensive perspective on the nature of ecological connections across regions.

(I) **Import relations:** This part of the research disaggregates and spatially deconstructs a country's external material ecological footprint. The empirical section opens with an example of this perspective (chapter VII). It quantifies U.S. import of a large number of renewable resources products based on material flow analysis[2]. The quantities of import products are then converted back to their fresh / raw equivalent weight and then into a productive land area equivalent: the amount of land devoted in each producer country to growing those products. The resulting figure represents the external material footprint of the importing nation on the exporting one.

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[2] For the list of imported products included in my study see table 1 in section II of this chapter.

(II) **Export relations:** Both Costa Rica (chapter VIII) and Canada (chapter IX) export to more than one other country. I take a producer or exporter perspective, asking what proportion of total production do exports represent? What are the main export destinations? How many and what quantities of physical inputs (such as land, water and chemicals) are required for the production of those export products? and how much ecosystem area in each study nation is devoted to export? Answers to these questions illustrate the ecological complexity of world trade and help reveal the role of trade flows driving ecological change in exporting countries.

(III) **Specific region and Products relations:** Both perspectives discussed above help to disentangle global trade and its ecological effects. They follow resources from a producing country to consuming one reveal the extent of one country dependence upon the terrestrial ecosystems of another. However, to make explicit connection to specific processes of ecological changes within the exporting country I take a specific region or product approach. This approach details the production methods, types and rates of physical inputs and ecological impacts of growing / producing in a specific region or associated with specific products in the exporting country. Ideally I should document all producing sectors and regions within the exporting studied nations, analyzing each product and its contribution to ecological deterioration. However for practical reasons this study will focus on only a few major export products and regions.

Figure 3 presents the components, the steps taken in the empirical research (chapters VII-IX):

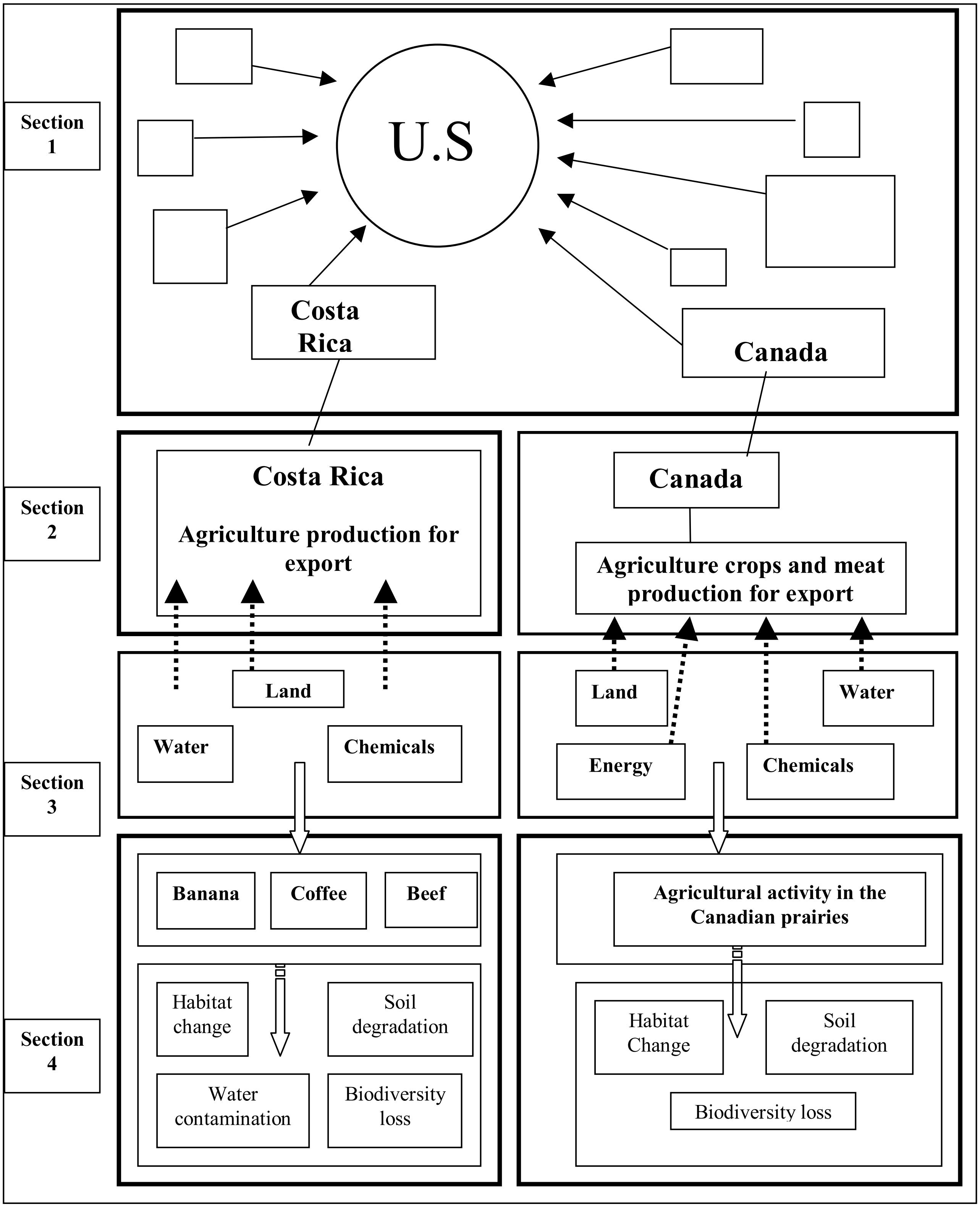
(a) The first section (the upper part the figure) quantifies the flow of resources into the United States from a large number of countries around the world; it then calculates the amount of land required in each country to grow / produce those resources, giving the size of the U.S. material ecological footprint on each country.

(b) The next section focuses on Costa Rica and Canada as two representative export case studies. It documents the flow of a large group of renewable resources, grown / extracted within these countries and exported to the U.S. and to the rest of the world; it illustrates the scope and scale of interregional connections between these nations.

(c) The next section estimates the amount of inputs devoted to growing export products in each of these countries.

(d) Finally the last section traces links between specific products (bananas, coffee and beef in Costa Rica, and agriculture activities in the Canadian Prairies) and four ecological changes - habitat change, soil degradation, biodiversity loss, and water contamination.

Figure 3: The research components



6.2 Finding correlations – production, consumption and ecological change

This research aims to do both: to describe and quantify the interregional material linkages between selected countries and to investigate some of the connections between ecological damage in one country and the export of biophysical goods to other countries. In the following paragraphs I discuss what I believe can be measured and documented, and how I approach each of the research goals.

6.2.1 Physical inputs

The analysis focuses on four physical inputs upon which any production and consumption depends and which are related to ecological deterioration: land; water; chemicals; and energy. Most human activities involve the use of some or all of these physical inputs. As discussed further in the following paragraphs, connections between these inputs and specific ecological change are not always straightforward; still while there are several drivers to ecological change, almost all changes can be followed back to the use of these physical inputs (e.g., deforestation to the use of land for agriculture; biodiversity loss to the use of land and chemicals; etc.).

Specific ecological change processes are quite often poorly documented. Nevertheless, the amount of physical inputs involved in production can indicate potential and actual pressures - the more inputs we use the higher the potential impact. Moreover, in the context of this dissertation, describing and quantifying the physical inputs in one country needed to support another emphasizes the material linkages between those countries; i.e. the level of dependence of one country on another and on the availability and quality of the physical inputs in that country.

As mentioned previously however, data availability and time constraints limit detailed consideration in this research to some of the connections between these inputs and processes of land degradation. The major documented inputs are land use; the other inputs have been only partially documented. I hope future study will continue and elaborate on other physical inputs and other aspects of ecological change.

6.2.1.1 Land inputs

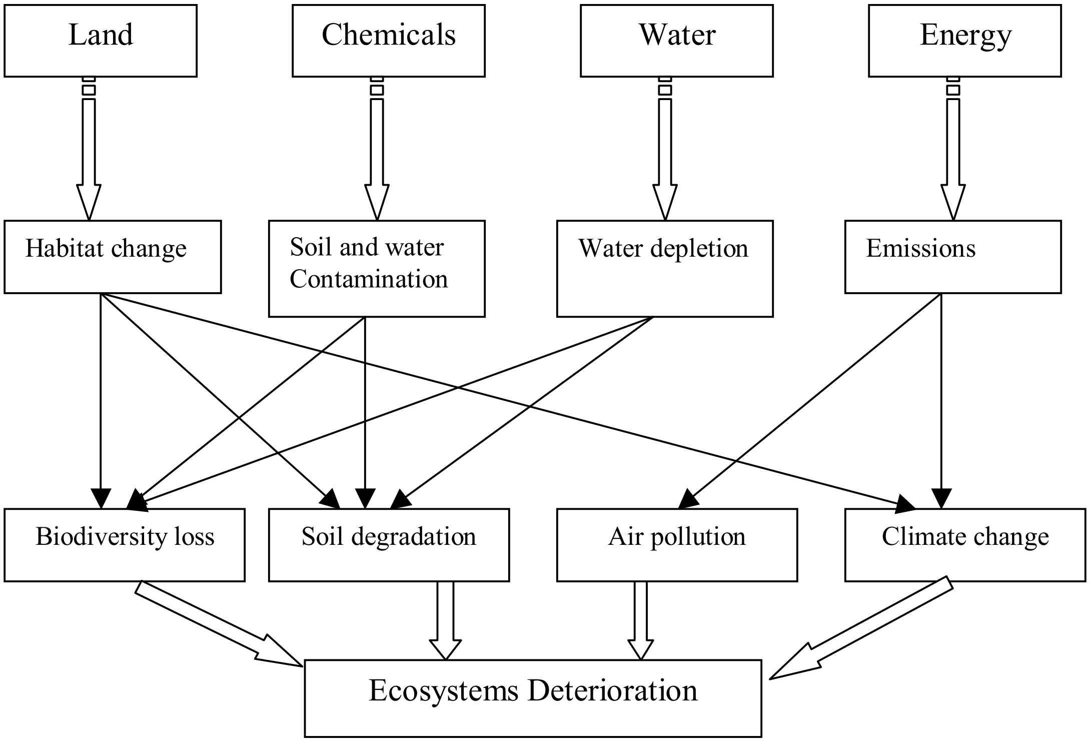
Land (i.e., terrestrial ecosystems) use is a major indicator of humankind-ecosphere relationships and a key to understanding ecological degradation. Human use of ecosystems reflects humanity's de facto ecological "niche" (Rees 2001). Historically, humans have drawn a significant portion of their needs from terrestrial ecosystems. Despite the partial substitution of fossil fuel and mineral-based fertilizers for natural fertility, bio-productive land remains a critical substrate and important source of matter contained in food and fibre supplies (Darwin et al. 1996; Young 1998). Land and solar energy provide more than 95% of human food, the greater part of clothing, and all forms of wood fiber (Mather 1984; Young 1998). As noted previously researchers have estimated the amount of land directly and indirectly occupied by humans and that have been modified for human use in the past few decades (e.g., Hannah et al. 1994; Sanderson et al. 2002; Vitousek et al. 1986; 1997; WWF 2006). Although differing in detail, the overall picture is the same – humans have already transformed up to 50% of the land on Earth for their direct economic use.

The capacity of terrestrial ecosystems, and more generally, of nature's life-support services, to sustain growing human demand is a fundamental sustainability issue (MEA 2005; Turner and Meyer 1994; Mather 1984). Meyer and Turner (1994) emphasize that the modification of the earth by human action mainly involves efforts to increase the productivity for people of these ecosystems. While the agricultural revolution was a major driver for such changes other more recent drivers for the acceleration of land transformation are: the industrial revolution, the globalization of the world economy, and the expansion of population and technological capacity. Dudley et al. (1995) and Lambin et al. (2001) refer to international trade and the growing demand for products, as an additional major reason for land-use and land-cover change all over the world.

6.2.2 Documenting some of the correlations between production, physical inputs and ecological integrity decline

After documenting production for export and some of the physical inputs involved, I made an effort to make more explicit connections to specific ecological change. LCA researchers have made an effort to model some of the connections between different physical inputs involved in production and their ecological consequences (e.g., Owens 1997; Goedkoop et al. 1998; Udo de haes et al. 1999; Kolner 2003). I used these studies to construct the following figure showing some of the relationships.

Figure 4: physical inputs and ecological changes



As noted, land degradation is the major aspect of ecological change studied here. Stocking and Murnaghan (2001:9) and Lal et al, (2004) see land degradation as a composite term which describes how one or more of the land resources (e.g., soil, water, vegetation) has changed for the worse. The FAO (1999) defined the process as: “the temporary or permanent decline in the productive capacity of the land”. Under that term there are several elements such as: landscape alteration; soil depletion; water deterioration; loss of biodiversity; and land pollution, which contribute to the process of land degradation and which create pressure on supporting ecosystems (Daly 1997). In the following paragraphs I summarize the elements of land degradation studied and documented in the Costa Rica and Canadian chapters.

Land use and land cover change (LULC) – LULC changes contribute significantly, both directly and indirectly, to land degradation and ecological change. For example deforestation will almost always contribute to the acceleration of soil erosion, nutrient loss, sedimentation of lower slopes, and increased surface runoff. Such runoff from agricultural lands contributes to the pollution of surface water bodies and downstream flooding (Stocking and Murnaghan; 2001:7).

Soil depletion- Soils are one of the most important resources for humans (Gregorich 1995). Soil can be defined as the body that forms the uppermost layer of the earth's crust (Lal et al. 2004). It provides a matrix for plants supports all terrestrial life, filters and purifies water, biodegrades pollutants, and moderates gaseous exchange between terrestrial and aquatic ecosystems, and the atmosphere.

Dindal (1992) writes: "Soil is a living system - complicated, often heterogeneous, its nature completely dependent upon its physical, chemical, and biological properties, filled with thousands of species and millions of individuals".

Soil degradation means adverse changes in soil properties and processes over time. These changes can be a result of natural or anthropogenic perturbations (Lal et al. 2004:4). Soil degradation can lead to the reduction in its ability to perform any of the above life support functions. While natural changes are mostly slow processes to which soils have time to adapt, anthropogenic activities are mostly rapid, disturb the delicate balance between soil and its wider environment, and lead to drastic alteration in soil properties and processes.

Lal et al (2004) make a distinction between three major kinds of soil degradation –physical, chemical, and biological. It is the interaction of the three which leads to the decline in soil quality. Physical erosion leads to a breakdown of the soil structure, compaction of surface and subsoil, reduction in water infiltration capacity, and increase runoff rates (Lal et al. 2004). Chemical degradation means negative changes in soil reactions or in the quantity and availability of nutrients. It includes chemical leaching or the depletion of plant nutrients and pollution of soil by introduced substances. Biological degradation means a change in soil structure or function resulting from a decline of soil biological activity, the reduction of biodiversity, or a change of the species composition in the soil.

Biodiversity loss - The more we study ecosystems, the clearer it becomes that we still have not identified most of the existing life forms. For example, according to UNEP (1995) worldwide known species are 1,750,000, while the estimated number of existing species (not including many bacteria, fungi and other micro forms) is about 14,000,000. Biodiversity is greatly affected by land degradation. Biodiversity has always played an important role in ecosystem resilience (Groombridge and Jenkins 2002; Folke 2006). Ehrlich and Wilson (1994 as cited from Sanchez 1996:40) suggested three important reasons for concern regarding biodiversity loss: 1) ethical and aesthetic considerations. 2) The direct loss of economic benefits from biodiversity in the form of foods, medicines and other industrial products. 3) Loss of essential services provided by ecosystems, of which diverse species are key working parts.

To make some of the linkages between production, the use of physical inputs and the elements of land degradation presented above, I reviewed studies that document the state of ecosystems at different scales over time in the exporting case study country / region. Four different kinds of studies are used to support this part of the research - *natural sciences studies; agricultural sciences studies; land use land cover change studies; and state of the environment reports*. While these categories of reports are related, the focus of each is different and contributes to documenting connections between production and pressure on ecological systems.

(I) *Natural science* (mostly Ecology) - These studies document many aspects of natural systems, from species composition to ecosystems function. While the traditional focus has been on documenting systems structure and function, some studies also address such issues as productivity, resilience, and the impacts of different activities. The scale of the latter studies is generally small, looking at specific research plots within relatively pristine areas such as natural reservations.

(II) *Agricultural sciences* – The agricultural studies I consulted were divided into those focusing on agriculture productivity and ways to make it more efficient (and profitable), and studies that document different environmental and ecological consequences of agricultural activities. For example, studies on fertilizer use are divided into those investigating the optimal application for increasing yields and reducing inputs, and others which focus on issues such as nutrient balance and leakages into the surrounding environment. The scales range from a specific field to a whole region; from single to multiple products.

(III) *Land use land cover studies (LULC)* – Increasing land cover change all over the world for human purposes has stimulated an increasing number of studies that document and explore the drivers of this process. The development of technical tools such as remote sensing and geographical information systems has contributed greatly, increasing data availability and accuracy. Both land use and land cover changes are relevant to understanding ecological changes at the regional through the national to the global levels.

(IV) *State of the environment reports* - A growing number of jurisdictions are publishing reports documenting different aspects and scales of environmental change. These reports are highly relevant to my study. Many of these studies document change at regional or national scale and trace some of the drivers of those changes.

6.2.3 Issues of data

While studies belong to each of the above categories can help in making the required linkages, I identify several constraints: (I) Data availability – Some processes are documented better than other. While some data are documented on a monthly or yearly basis, other data are sparely documented or not exist at all. For example while data on production and trade flows are relatively well documented and accessible, data on processes of ecological changes are more sporadic, some aspects covered better then other. (II) Analysing interdisciplinary data – To make the linkages discussed above I combined data from very different kind of sources. While such interdisciplinary approach is essential for such research and is one of the potential contributions of this dissertation, analysing such interdisciplinary data is a challenge. The focus of each of these disciplines is different and so are the kinds of data they document. Moreover, usually the purpose of documenting different data has nothing to do with the attempt to find correlation to other processes, for example: trade data are mostly not gathered to be connected to data on ecological changes; ecological studies on biodiversity in certain field are usually documented for the sake of science and mostly do not look for the human activities that might risk that diversity. (III) Analysing data across scales - While data on production and trade are usually at the national scale, many of the focus of the other sources is quite often on very small scales such as specific field or forest and in many cases, as in many studies in the natural sciences, on a single or a group of research plots.

The multi dimension, cross scale, approach I am taking here and discussed above (i.e. import, export and product/region), help to overcome some of these data constraints. I embraced and documented some interregional connections for each scale. The data used for the import and export dimensions were mostly at the national level and involved quantitative data at that scale – including data on production, physical inputs, trade data, consumption levels etc. I then use data on processes of ecological changes at the national and regional scales. Finally the focus on specific products / region, allows me to use data from the agricultural and natural sciences to make the correlations between specific production activities and ecological changes (e.g., bananas and deforestation). Still, the constraints discussed above are significant and only some of the correlation could be made other should be part of future study.

6.2.4 Direct, indirect, or minimal potential impacts

Human activities can lead directly and indirectly to pressure on supporting ecosystems; different activities result in different consequences and varied levels of impact. Some forms of ecological degradation can be directly connected to specific activities. However, in many cases impacts are a consequence of more than a single driver or activity. While my main focus is on the direct impacts, I also document some indirect impacts. Finally I describe some relevant activities that have only minimal negative consequences to illustrate the differences among various production methods.

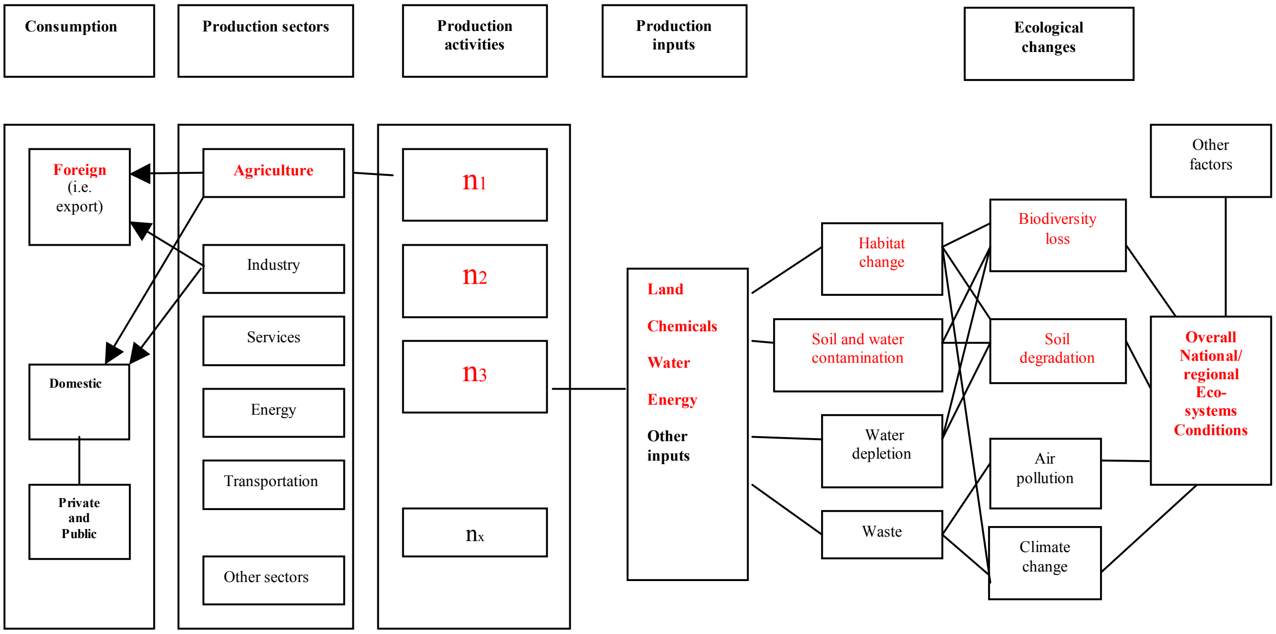
(I) **Direct impacts** - The direct consequences of producing specific products. I identify the amount of product produced, document the various physical inputs required for production and connect this production to ecological change particularly in land cover, soil quality and soil and water contamination.

(II) **Indirect impacts** – I also explore some indirect impacts on ecosystems which are beyond the area of the field / plantation but can partly connected to the activities documented. However, this part of the research is mostly qualitative: the contamination of neighboring ecosystems is an example of indirect impacts revealed in this study.

(III) **No or minimal impacts** - Growth / production of the products selected for this study does not necessarily place significant pressures on their ecosystems. There are many examples of more sustainable production and consumption. In this part of the research I document some of the differences between conventional methods of production (i.e., growing, harvesting, and packing) and alternative certified methods where lower impacts are evident.

To reiterate, I examine drivers of ecological change and connect them to the production of specific agricultural products. I describe some direct and indirect impacts of commodity production in the overall ecological changes recorded in the producing country / region (chapter VIII, Costa Rica and IX, Canada). Therefore I open each of these empirical chapters by describing the relevant national/regional ecological systems and then outline ecological changes in those systems over time as documented in available sources. The next step is to understand what role the agricultural sector plays in ecological changes within the country. Finally, I trace connections between specific agricultural products (chapter VIII) and production in specific region (chapter IX) and observed processes of ecological changes. Figure 5 summarizes my approach and section II describes this process in detail.

Figure 5: The research focus



6.3 Research phases

This section presents the basic research step by step, describes each of the research phases, identifies major data sources, states the assumptions made, and describes which data are still missing and will have to wait for further research. I divide this section into two parts: the first discusses material flows and the land and other inputs required for production in each studied case; the second presents correlations between production and ecological change.

6.3.1 Import case study - Tracing the external material footprints of the U.S.

6.3.1.1 Identification and selection of renewable resources imported into the U.S.

The first step was to identify renewable resource products imported into the U.S. from around the world between 1995 and 2005[3]. Next, a large group of products was selected for analysis, together representing most agricultural products and other renewable resources consumed in the U.S. The study includes 86 products in their raw material stage (table 1) and more than 110 manufactured products (for the complete list of products please see appendix 1 table 1). The products are grouped into ten categories: Fruits; Grains; Legumes; Oil Crops; Nuts; Stimulants; Vegetables; Fibres; Beef; and Wood products (Table 1). I recorded the weight (metric tonnes – Mt) or volume (Cubic meter – M3) of the imported products.

Many of these products are consumed only after industrial processing (dry; canned; frozen; oil; juice; meat products; etc.). As my goal was to trace product sources and to estimate the key inputs (land, water, chemicals and energy), I converted most products back to their raw material equivalent, to enable estimates of the inputs needed to produce the raw product[4].

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[3] Major sources were:
FAOSTAT (2007) @ http://faostat.fao.org/default.aspx;
USDA-ERS (2005) Food availability spreadsheets @ www.ers.usda.gov/data/foodconsumption/FoodAvailSpreadsheets.htm
USDA-FAS (2007) Production, supply and distribution online @ www.fas.usda.gov/psdonline/psdquery.aspx
USDA-FAS (2006) U.S trade internet system @ www.fas.usda.gov/ustrade/
USDC - ITA (2006) Industry trade data and analysis @ http://trade.gov/index.asp

[4] The two major sources for those conversions were:
USDA-ERS (2005) Food availability spreadsheets @ www.ers.usda.gov/data/foodconsumption/FoodAvailSpreadsheets.htm
FAO (1996) technical conversion factors guide @ www.fao.org/es/ess/index_en.asp
I also used several specific industry sources for such crops as: sugar, coffee, and juices.

Table 1: Raw products covered in the study

Fruits	**Vegetables**	**Grains**	**Stimulants**	**Meat**
Apples	Asparagus	Wheat	Coffee	Beef
Apricots	Eggplant	Rye	Tea	Lamb
Avocados	Broccoli	Oat	Cocoa	
Bananas	Cabbage	Maize	Sugar	
Blueberries	Carrot	Rice		**Wood**
Other berries	Cauliflower	Millet	**Oil crops**	Logs
Strawberries	Celery	Barley	Flaxseed	Lumber
Cherries	Cucumber		Groundnuts	Plywood
Dates	Garlic		Mustard seed	Pulp wood
Figs	Ginger	**Legumes**	Soya	Paper
Grapes	Lettuce	Beans	Olive oil	
Grapefruits	Mushroom	Chickpeas	Sunflower	
Kiwi	Okra	Lentils	Palm	
Lemon	Onion	Peas	Rapeseed	
Mangos	Potato		Safflower	
Melons	Pepper	**Nuts**	Sesame	
Olives	Spinach	Almonds		
Oranges	Tomato	Brazil nuts	**Non food**	
Papayas	Yam	Cashew Nuts	Cassava	
Pears		Hazelnuts	Cotton	
Peaches		Pistachios	Jute	
Pineapple			Rubber	
Plums			Sisal	
Watermelon			Tobacco	

6.3.1.2 Tracing the sources of imported products

The next step was to identify the sources of each of the products. Overall I documented trade flows from 59 countries to the U.S. While these countries are the major U.S. trade partners for the products studied here, other countries also export products to the U.S. directly or through a third country (i.e., exporting raw material that is being processed and re-exported to the U.S.). I followed the flow of resources only one step back, which means that trade of several products with certain countries were not covered. For example the U.K is a major exporter of tea, but tea is not grown in the U.K at all. The same is true for coffee from Germany or Italy, sugar from Iceland and so on. Overall, the study covers 94% of the imported fruit weight, 89% of grains, 94% of legumes, 97% of nuts, 95% of oil crops, 93% of stimulants, 86% of vegetable, 56 % of fibers, 99% of meats, and 80% of wood volume.

In order to trace the source of different resources imported into the U.S. within the study period, a few conditions for inclusion had to be made:

(a) The imported product was grown / manufactured in the exporting country – The global trade system is complex, and in many cases it is difficult to trace the source of different raw materials. I make an effort to ensure that the products studied were grown in the exporting country. To do that, one of two conditions must apply: first, the exporting country must not import any amount of the product from another country. Second, if it does import the product, the amount imported must be smaller than the amount it produces.

(b) The imported product has been consumed in the U.S. – Some products are imported and then re-exported either in the same form they were imported (e.g., bananas re-exported from the U.S. to Canada) or as manufactured product. In order partly to overcome this problem, the data sources I used for import data make a distinction between import for consumption and import for re-export. However, I cannot be completely sure that some of the products or raw materials imported were not eventually exported.

Finally, for reasons of accuracy, the results presented here are conservative in terms of total trade flows. I follow only those products that can be documented with a high probability of meeting my criteria.

6.3.1.3 Estimating the terrestrial ecosystem area “appropriated” through trade

After collecting the data on the volume of trade flows, the next step was to calculate how much land is required in the exporting country to grow the export products. I considered each product separately and in the aggregate. This conversion is based on data on yield per hectare, taken from the FAOSTAT (2006) and compared where possible to data from national sources (e.g., MAG 2005; USDA2006; Statistics Canada 2005).

Assumptions made:

(a) National average yields –in many cases yields of the same product grown in different regions of an exporting country are significantly different. However, I used current national average yields, since in most cases product flows cannot be traced to particular regions in the exporting country.

(b) Accounting only for harvested land and not for planted land – there is sometimes a difference between the area of land that was planted and the area that was eventually harvested. Usually the harvested area is smaller for reasons of crop failure, or lack of profitable markets. The FAOSTAT yield data used for this chapter is based on the harvested land only and hence underestimate total cropland intended for export.

(c) Including only land required for actual imported products - I counted the land required for growing only the amount of product actually usefully imported by the case study nation ignoring the fact that a portion of exports regularly fails to reach its final destination. Products fail international / consumers' standards, cattle or other livestock die during transport and so on. Land whose products did not reach their destination has been excluded from the calculation. Again, this leads to a conservative estimate of 'exported' cropland.

6.3.2 Agriculture crops, pasture and forest land – estimating the land inputs needed for growing different products in specific locations around the world

The following paragraphs present the calculation procedure for several traded products: tomatoes, cotton, beef, and forest products. Each product represents a larger group of commodities where the calculation procedure is the same. I also discuss some of the issues and assumptions made in generating these estimates.

6.3.2.1 The case of tomatoes

The tomato calculation procedure represents method used for all other food crops.

a) Identifying the different tomato products imported by the U.S. – On average in the study period about 70% of the tomatoes imported were fresh. The remaining 30% are comprised of preserved tomatoes, dried tomatoes, tomato paste, ketchup, and tomato sauces.

Following the USDA conversion factors (USDA 2005) all product weights were converted to fresh weights using: Whole=1.553; Paste=5.432; Ketchup=2.457; Sauce=3.247. Thus, producing a kg of ketchup required on average 2.457 kg of tomatoes, and so on for the rest of the processed products.

b) The flow of tomatoes and tomato products into the U.S. from around the world – The U.S. imported tomatoes and tomato products from about 70 countries over the study period. However, after following the amount imported from each country it turns out that on average about 97% of that import weight originated from only 18 countries. Therefore, I decided to select these 18 countries with high probability that the tomatoes were actually grown in those countries. Most countries that were excluded in this case have either exported insignificant amounts of tomatoes or they are also major importers of tomatoes (e.g., the Netherlands, Belgium) , and therefore there is a good chance that the tomatoes they exported to the U.S. were grown in a third country. A third group of countries was excluded mainly for lack of data on production and yield.

c) Estimating the area of cropland – I estimated growing areas using yield data (productivity per hectare). The source I used for most yield data is the FAOSTAT (2006); these yield factors are based on total harvested land and production quantities at the national level; they do not make any distinction between different regions within the country, nor do they include differences between tomato types or production methods (e.g., field tomatoes versus greenhouse). After obtaining the average yield I divided the amount imported by the yield per hectare and estimate the area of land devoted to growing that export / import product.

6.3.2.2 The case of cotton

Following a commodity through the complex system of world trade is not simple and is too often impossible. However, as long as a product is in its raw material stage, it can be traced with a high degree of accuracy – e.g., one country grows bananas and exports them to other countries. Commodity flows become more difficult to follow when the product goes through an industrial process that changes its form and destination. This is the case for many products ranging from coffee, tea, bread and pasta, to furniture, automobiles, and many other manufactured products. In this section I focus on cotton and cotton products as an example of such manufactured products.

The problem: The U.S. is a major raw cotton producer and exporter and it is also a large importer of manufactured cotton products. On average over the study period the U.S. produced 4,089,700 Mt equivalent of raw cotton annually and exported an average of 72% of that amount. At the same time, most of the cotton products consumed in the U.S. are imported (USDA 2006). Thus it is possible that the U.S. consumes imported cotton products made from raw cotton originally grown in the U.S.

The calculation procedure – solving part of the problem:

a) Identifying the different kinds of cotton products the U.S. imports – As mentioned above most cotton products consumed in the U.S. are imported. These products include raw cotton and cotton yarn as well as textile products such as fabrics and apparel. The first issue is the conversion of textile product into its raw cotton equivalent. I include only products that contain 85% or more of cotton. That group of product represents most of the import (USDC - ITA 2006). The other issue is the fact that most textile products data are in square meters and not in weight. The USDA (2006) publishes data on both U.S. raw cotton and cotton product imports, and the equivalent raw material needed to produce these amounts. For example on average within the study period more than 1.36 billion square meter per year of textile products were imported to the U.S. estimated at around 3,100,000 Mt of cotton (USDA 2006).

b) The flow of raw cotton and cotton products into the U.S. from around the world - To trace the sources of the cotton and cotton products imported into the U.S. I used both the USDA (2006) and the U.S. Department of Commerce (2006) Textile Division data. To make sure that a cotton product imported into the U.S. was actually made out of cotton grown in the exporting country I chose only those countries that: (1) grow large amounts of cotton; (2) do not import raw cotton at all or import only small amounts; and (3) are major cotton products producers and exporters. While the U.S. imports cotton and cotton products from over 190 countries around the world, the research followed the flow of cotton products from only 17 countries that comply with the above terms. All together these counties represent an average of 30% of the cotton product imported into the U.S.

To further ensure that cotton products imported into the U.S. were not made from fibre grown within the U.S., I subtract that proportion of raw cotton imported to the exporting country from the U.S. from its exports to the U.S. For example, China is a major cotton products exporter to the U.S. (on average 11% of cotton imports by weight are from China). While China still grows most of its cotton, an average of 6% of Chinese cotton products are made out of cotton grown in the U.S. Therefore, I reduce the weight of cotton products imported from China by 6% to account for U.S. content.

Estimating the size of the supporting land - The final stage is to estimate the cropland area required to grow the cotton in each exporting country. I used both the FAOSTAT (2006) and the USDA-FAS (2007) for data on cotton yields in the countries studied. Again, I use national average yields and harvested land only.

6.3.2.3 The case of beef

Estimating the land inputs required for production of beef and other meat products is also a challenge in several steps:

a) Identifying the different kinds of beef products imported by the U.S. – the study includes U.S. import of both live cattle and beef products. The beef products include fresh and frozen beef and different prepared beef products converted back to their equivalent carcass weight. I used the USDA (2005) and the FAO (1996) conversion factors to estimate the number of livestock required to produce the meat products. The average yields of each animal (kg of meat/ animal) are different in different countries; I used both the FAOSTAT (2006) and the FAO-GAHLIPA (2006) for these data.

b) The flow of beef products into the U.S. from around the world - the major source of trade data for this section is the USDA-FAS (2006) and USDC-ITA (2006). I assumed that the meat products exported to the U.S. were extracted from animals grown and pastured in the exporting country.

c) Estimating the size of the supporting land – accurately estimating the supporting land for producing livestock and beef products is problematic. While estimating the size of the growing land for most plant crops is relatively straightforward the case of meat is more complicated:

(1) The first issue is that while both pasture lands and the arable land used to grow animal feed should be included, due to the lack of data for most countries, I was able to estimate only the pasture land area. Fortunately for the Canadian case (chapter IX) it was possible to include figures for of arable lands that produce feed for livestock.

(2) The other issue is how to estimate the 'exported' pasture land. I argue that an entire cattle herd is necessary to meet yearly meat production goals. In other words, to be able to continuously produce meat on a yearly basis, countries need a much larger inventory of livestock than that which is slaughtered or selected for export each year. To maintain that total livestock inventory a large amount of pasture land is required. The amount of pasture land needed for each year's meat production is in proportion to the number of slaughtered animals out of the total herd. As an example, in 1995 about 70,000 Mt of meat were exported from Argentina to the U.S. That amount represents 2.6 % of Argentina's total meat production in that year; therefore I assume that 2.6% of the available pasture land was devoted to produce that amount of meat.

6.3.2.4 The case of forest products

a) Identifying major wood products imported by the U.S. – This section does not cover the whole forest industry but rather focuses on the major groups of timber and wood products imported into the U.S.: logs, lumber, plywood, wood pulp and paper products. On average within the research period 24% of U.S. wood consumption was imported. In this study all wood products imported to the U.S. were converted to their round wood equivalent measures[5].

b) The flow of wood products into the U.S. – All together the U.S. imports timber and wood products from over 90 countries, however 97% of the imported logs, lumber and plywood come from only 7 countries, and 98% of the pulp and paper are imported from only 6 countries. In both cases Canada is the major source of wood and wood products imported to the U.S. (80% of the wood volume imported). For reasons of data availability the focus here will be on Canada[6].

c) Estimating the area of supporting land – After converting the imported wood and wood products to their wood volume equivalents in the exporting country, I used data on the amount of wood volume logged at that year and calculated the proportion of production devoted to export in general and to the U.S. in particular[7]. Finally, the area of forest devoted to grow export products need to be estimated. As in the case of pasture discussed above, I argue that to continuously be able to produce wood products year after year a large part of the overall forest is needed. Therefore I used data on the area of Canadian commercial forest and estimated that the same proportion of export out of production is the proportion of the forest devoted to grow export wood products[8].

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[5] Howard, J, L. (2003) U.S timber production, trade, consumption and price statistics 1965-2002 (USDA Forest service).

[6] Data for that part were taken from the USDA internet trade system (2006).

[7] National Forestry Database Program (2005) Wood supply in Canada (Canadian Council of Forest Ministers).
National Forestry Database Program (2007) Potential harvest estimates by ownership and species group (Allowable Annual Cut) 1990-2006.

[8] Natural Resources Canada (2001) Canada's National Forest Inventory.

6.4. Exporting case studies – Consuming Costa Rica and Canada

6.4.1 Identifying major export products

For both Costa Rica and Canada major export products were identified and quantified on a yearly basis for the period from 1994 to 2004[9]. In the case of Costa Rica I followed 29 major agricultural export products (Table 2); for Canada I followed the flow of 45 major agricultural products (Table 3).

Table 2 Costa Rica: Selected Export Products

Fruits	**Grains**	**Stimulants**	**Non food**
Avocados	Maize	Cocoa	Cassava
Bananas	Rice	Coffee	Tobacco
Berries		Sugar	
Grapefruit	**Nuts**		**Meat**
Lemon	Macadamia	**Vegetables**	Beef
Mangos		Cabbages	
Melons	**Oil Crops**	Ginger	
Oranges	Coconuts	Onions	
Papayas	Oil palm fruit	Tomatoes	
Plantains		Potatoes	
Strawberries		Yams	
Watermelons			

Table 3 Canada: Selected Export Products

Fruits	**Grains**	**Oil crops**	**Vegetables**
Apples	Barley	Canary seeds	Asparagus
Apricots	Maize	Flaxseeds	Carrots
Blueberries	Millet	Mustard seeds	Cabbages
Cherries	Oat	Rapeseeds	Cauliflowers
Cranberries	Rye	Safflowers	Cucumbers
Grapes	Wheat	Soya	Lettuces
Melons		Sunflower	Mushrooms
Peaches	**Legumes**		Onions
Pears	Beans	**Non food**	Peppers
Plums	Lentils	Hay	Pumpkins
Raspberries	Peas	Tobacco	Spinach
Strawberries	Buckwheat		Tomatoes
Watermelons		**Meat**	
		Beef	

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[9] FAOSTAT 2006 @ http://faostat.fao.org/default.aspx

Ministerio De Agricultura Y Ganaderia (MAG). 2004. Memoria 2004 (San Jose, Costa Rica).

STATCAN-COA (2007) Census of Agriculture (Statistics Canada)

These products are exported as both fresh / raw products and manufactured products. Some examples include: bananas – while most exported bananas are fresh, some are exported in the form of baby foods, or dried bananas; oranges – while Costa Rica exports some fresh oranges most oranges exported from that country are in the form of juice; coffee – all exported coffee goes through some processing (washing, drying and in some cases roasting); wheat – some wheat is exported as raw material while a significant portion is exported as either flour, pasta and other manufactured products; beef – most meat products are exported after some level of processing, although some is exported as livestock. The significance of this twofold: first, certain data on export amounts needed to be converted back to fresh / raw form in order to estimate the land and other inputs involved in growing specific products (see the U.S. case for a detailed explanation). Second, the processing of different products involves an extra amount of inputs (energy, water, chemicals); and although the main focus of this study was the growing phase, some of these extra processing inputs were counted as well.

One major assumption made here was that the exported products are grown in the exporting country – I made sure that all the studied products were actually grown in the exporting case studies. I counted products that were either entirely produced in the exporting country and are not imported at all from a third country (e.g., bananas in Costa Rica), or that their rate of import to the exporting country are smaller than the amount produced within the country (e.g., oranges in Costa Rica or beef in Canada).

6.4.2 Identifying major export destinations

The next phase was to identify the major export destinations – those countries that have direct interregional connections with the exporting country[10]. While the U.S. is a major destination of export for both Costa Rica and Canada, other regions of the world were counted as well: For Costa Rica – the European Union, Central America and the rest of the world; for Canada – the European Union, Latin America, Asia, and the rest of the world.

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[10] Several trade data sources have been used for this section:
FAOSTAT (2007) @ http://faostat.fao.org/default.aspx
UN com trade (2006) @ http://comtrade.un.org/db/
CHASS (2007) Canada's trade analyser @ http://datacentre.chass.utoronto.ca/trade
Statistics Canada (2006); Grain trade of Canada 22-201-XIB
Industry Canada (2007) Trade data online @ http://strategis.gc.ca/sc_mrkti/tdst/engdoc/tr_homep.html

One assumption made here is that all exported products are consumed in the importing country. While there is a good chance that parts of the products were re-exported as either raw materials or after manufacturing, in this study I follow the products only one step from growth/production to their next destinations.

6.4.3 Terrestrial ecosystems devoted to export

The next stage was to convert the export products into their growing area equivalents. To do that I used both national and international estimates of yield per hectare for each studied product[11]. I again assumed average national yields rather than attempt to reconcile the different yields in different parts of the country. In Costa Rica the yields were based on harvested land and not cultivated or planted land (see the U.S. case for detailed explanation). Therefore the results are quite conservative and lower than actual dedicate land values. For Canada, the yield data included both cultivated and harvested lands and are therefore probably more accurate. In both cases I included only the land required for growing products actually consumed in the importing country, ignoring the fact that while growing different products, part of the production does not reach the final destinations. Land whose products did not reach their destination has been excluded from the calculation.

6.4.4 Other inputs involved

Of the four physical inputs to agricultural production identified in this research, land is the input assessed in detail. Indeed, in the U.S. as importer case, land required for growing products is the only input accounted for. In the exporting country examples land is also the key input examined but I do make an effort to account for some other inputs involved in growing / producing different export products.

Chemicals – The total amounts of both commercial fertilizers and pesticides involved in growing export products has been estimated. For Costa Rica, I assume national average application rates in the absence of regional data. In Canada chemical inputs were calculated for both the national and Prairie Provinces levels. For both cases, data sources are international, national, sectoral and academic.

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[11] FAOSTAT (2007) @ http://faostat.fao.org/default.aspx
Ministerio De Agricultura Y Ganaderia - MAG (2005). Memoria 2004 (San Jose, Costa Rica).
Statistics Canada (2005) – Catalogue No 22-003-XIB

Water – For both exporter cases, the amount of water required for producing export products was included. I do not make a distinction between irrigation and natural use of water and do not address the issue of the different potential consequences of using water in different locations. The major data sources accessed were international studies on Virtual water (Allen 1998) and water footprints (Hoekstra and Chapagain 2002; Chapagain and Hoekstra 2004).

Energy - Only some aspects of energy inputs were counted and only for the Canadian case, where data were available. As energy issues are important and can be connected to several classes of ecological changes, I hope to include energy use impacts in future research.

6.4.5 From product consumption to ecological impact

After identifying major export products and documenting the inputs involved in their production, I tried to estimate the extent to which the production of those products can be connected to ecological change in the exporting nations. It is beyond the scope of this dissertation to cover all ecological changes and all activities at cause. Instead I focused on: (1) Overall national / regional eco-systems conditions; (2) Specific sectors and (3) Specific region / products.

1. Overall national / regional eco-systems conditions – this section begins with a general discussion on the natural environment and documented processes of ecological changes in the export study regions. The focus is on land degradation examining the same elements that are discussed in analyzing specific products: habitat change; soil degradation; water contamination; and biodiversity loss. Data for this section are from a large group of studies and reports from several fields (see paragraph 2.2 in section I of this chapter).

2. Focus on specific sectors – This part of the research discusses the role of the agricultural sector in the overall ecological changes documented for each nation/region.

3. Focus on specific products / region - To establish connections among production of specific products, processes of land degradation and ecological change, this section correlates the use of physical inputs for production with direct (and some indirect) ecological changes. In the case of Costa Rica I focus on three major export products – bananas, coffee and beef. In the case of Canada the focus is on the prairie region where grain, oil seed, legumes and beef are major products. For the prairies, however, the discussion remains at the regional level, rather than the product level. The focus is on the connection between agricultural activity in that region and such ecological changes as: habitat change, soil degradation, land and water contamination and biodiversity loss.

While inputs required for producing any product implies potential pressures on supporting ecosystems, this research adds an innovative dimension to existing literature by studying some of the connections between physical inputs required for production of specific products and documented ecological changes for the producing region (see paragraph 2.2 in section I, on documenting some of the connections).

As noted, I include both quantitative (e.g., area of forest land converted to banana plantations) and more qualitative connections (e.g., the connections between deforestation rates within Costa Rica's major banana growing area and actual expansion of banana plantations). I consider some direct and indirect connections between specific production activities and documented ecological changes. For example: water contamination – the direct correlations documented by studies which measured on site contamination; such measurements can support an argument for direct correlations between production of export products and ecological change. However, in several cases, the documented data can only partly be correlated to the production of specific products for reasons such as the lack of on site data, data are from nearby areas only (i.e., downstream, or measures taken in protected areas).

The following chapters present the results of each of the cases examined.

Chapter VII
The interregional ecology of the United States - or Tracing the external material footprints of America

7.1 Overview

The United States of America (U.S.), the world's largest economy, is a major producer and exporter of a wide variety of natural resources; it is also a huge consumer of resources grown / extracted from its own territories and from around the world.

In this chapter I take the first steps in documenting the interregional connections of the United States. I trace the sources of renewable resources consumed within the U.S., document their flows and quantify the corresponding American external ecological footprint[12]. The chapter opens with a summary of renewable resource materials imported (by weight or volume) by the U.S. during the research period, and a calculation of the land inputs required to grow/produce this quantity of resources. As my goal is to describe and quantify the interregional material linkages between selected countries and to investigate the connections between production for export and ecological changes, I disaggregate the external footprint of the U.S. to estimate the material footprints of specific products on different countries.

I traced 86 import commodities to 59 source countries. On average these countries are the sources for 90% of the weight of import commodities included in this study (Green colored countries on Map 1). The commodities comprise three categories: agriculture crops, meat products and wood products. Table 4 presents annual imports of each category by weight. Overall, in the study period the U.S. increased its import of renewable resources. Forest product imports have annually increased by an average of 3.8% (an increase of 45.3% from 1995 to 2005). Beef import has annually increased by an average of 6.2% (an increase of 76.6% from 1995 to 2005). Agricultural crops imports have annually increased by an average of 4.8% (an increase of 51.3% from 1995 to 2005). Table 5 presents the estimated total area of land required to produce the imported products[13]. The data shows an annual average increase of 2.3% (an increase of 23.5% from 1995 to 2005) in the overall size of the external material footprint.

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[12] This chapter does not include non-renewable resources or energy inputs. For a detailed discussion of the methods and the data sources see chapter VI which describes the material component of the ecological footprint (agriculture, pasture and forest land) but does not cover the 'energy lands' required to sequester greenhouse gases emitted in production.

[13] While the volume of wood products in table 4 covers overall import, the forest land (table 5) is only in Canada.

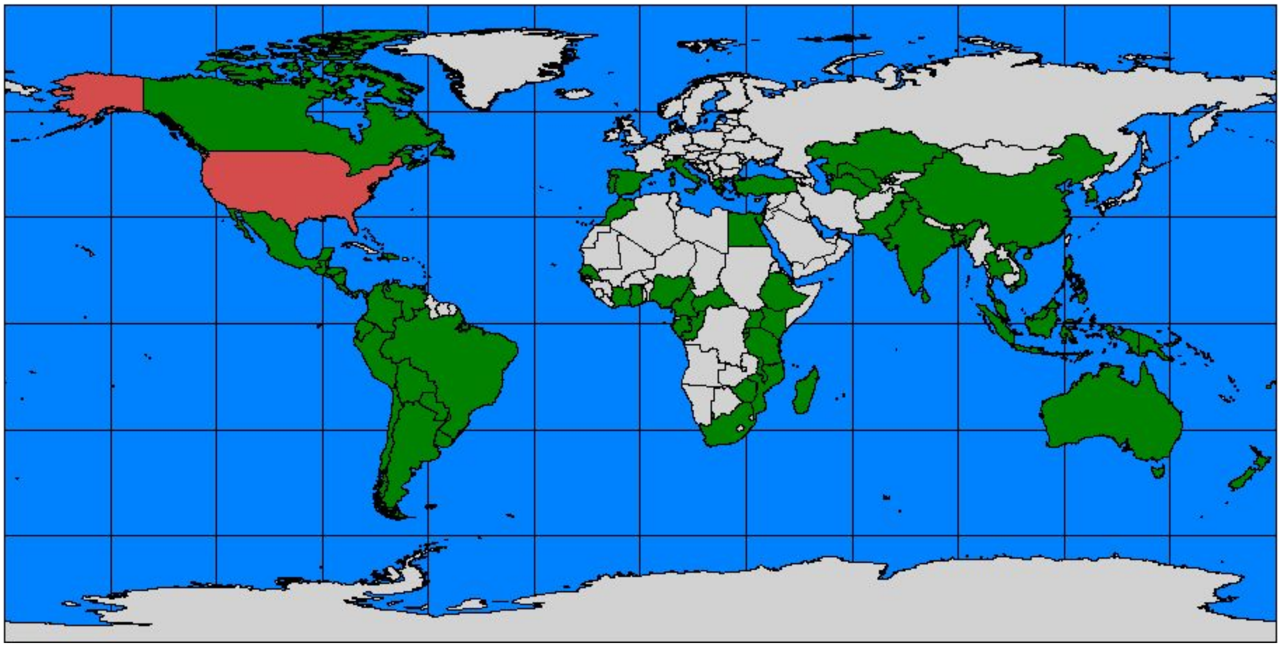
Table 4: U.S. imports 1995-2005 (1000s' Metric tonnes/Cubic meters)

1000s Mt	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agricultural crops	44,890	60,020	63,510	55,580	56,160	53,330	51,840	53,740	57,630	60,840	67,930
Meat products	987	984	1,118	1,276	1,386	1,469	1,536	1,564	1,464	1,780	1,743
Wood products	110,725	111,099	114,941	121,872	129,046	131,578	133,810	138,440	140,931	153,401	160,842

Table 5: Land 'imported' by U.S. consumers 1995-2005 (1000s' hectares)

1000s ha	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Agricultural products	11,680	12,210	14,040	14,480	13,790	14,590	15,840	15,930	16,280	17,140	16,880
Meat products	48,000	36,010	40,060	45,190	47,830	54,000	54,900	53,180	55,670	61,940	61,140
Wood products	74,671	78,420	76,323	84,508	78,414	78,464	85,658	82,309	89,220	77,354	87,893
Total	**134,351**	**126,640**	**130,423**	**144,178**	**140,034**	**147,054**	**156,398**	**151,419**	**161,170**	**156,434**	**165,913**

Map 1: The documented countries



The above data (table 4 and 5) describes the overall material flows into the U.S. and the U.S. external material footprint. These results aggregate the production and import of many products, each involving different land inputs and, as discussed in details in the following chapters, lead to different ecological impacts. The rest of this chapter analyses each resource category - agriculture, meat, and wood products - and characterizes the external U.S. material footprint on specific source countries around the world. It presents the regions and countries, with which the U.S. has interregional connections and highlights the products that are mostly imported. It also presents the results of calculation of the equivalent fresh / raw imported products, the area of land devoted to specific imported products in each supporting country; emphasizing products and sources that required the largest area of land. Analysing and identifying specific components of the external footprint, as presented here, can imply for the scope of U.S. impact on specific countries and the part of each commodity. It also highlights the commodities and sources that can contribute the most to future reduction of that external footprint.

7.2 The product level – where do specific products come from?

7.2.1 Agricultural products

Agricultural crops were aggregated into several groups comprising most of the agricultural commodities imported by the U.S. Table 6 summarizes the flow of agricultural products into the U.S. during the research period (see also appendix 1 table 2).

Table 6 U.S. agricultural crop imports 1995-2005 (1000s' Metric tonnes)

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Fruits	10,080	11,340	11,740	11,970	13,710	13,390	12,740	13,200	14,490	14,250	16,170
Grains	5,690	5,200	6,800	6,320	6,620	6,120	6,870	6,310	5,360	5,690	5,480
Legumes	180	180	210	210	240	260	320	390	400	450	430
Nuts	80	220	250	250	280	320	320	360	390	500	450
Oil crops	7,610	9,090	9,970	9,500	11,700	10,700	10,210	10,880	12,590	15,390	14,740
Stimulants	16,320	28,590	28,790	20,840	16,900	15,860	14,540	14,750	16,100	15,790	21,870
Vegetables	2,910	3,310	3,490	4,060	4,250	3,990	4,370	4,800	5,140	5,460	5,490
Fibers	2,030	2,090	2,260	2,430	2,460	2,710	2,480	3,050	3,150	3,320	3,300
Total	**44,890**	**60,020**	**63,510**	**55,580**	**56,160**	**53,330**	**51,840**	**53,740**	**57,630**	**60,840**	**67,930**

Within the study period the overall average annual weight of agricultural imports was 56,550,300 Mt. Over the course of the study period the overall import weight increased by factor of 1.5. Still, while the general trend was an increase of import, this is a crawling increase. As shown in table 6 and analyzed in the following paragraphs of this chapter, some agricultural crops showed more significant increase then other. Also as some commodities show a clear linear trend in other the trend is not that clear. Table 7 presents the land inputs required for production of the above imports. On average within the study period 13,482,700 ha/year were devoted to growing these agricultural products for consumption in the U.S. The U.S. external cropland eco-footprint had constantly increased over the study period by a factor of 1.3; an average yearly increase of 532,000 ha (see also appendix 1 table 3).

Table 7 Land devoted to production of U.S. agricultural import 1995-2005 (1000s' hectares)

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Fruits	660	670	690	740	790	780	740	820	860	850	970
Grains	2,260	1,900	2,820	2,530	2,410	2,360	3,100	2,910	2,120	1,990	2,100
Legumes	100	90	110	110	120	140	180	240	220	260	250
Nuts	180	480	650	1,130	580	700	740	670	700	850	670
Oil crops	2,130	2,220	2,490	2,450	2,450	2,550	2,800	2,590	2,520	3,300	2,780
Stimulants	3,400	3,790	3,760	3,690	3,810	3,860	3,510	3,060	3,470	3,460	3,640
Vegetables	170	190	190	210	220	220	240	270	270	280	300
Fibers	2,780	2,870	3,330	3,620	3,410	3,980	4,530	5,370	6,120	6,150	6,170
Total	**11,680**	**12,210**	**14,040**	**14,480**	**13,790**	**14,590**	**15,840**	**15,930**	**16,280**	**17,140**	**16,880**

While agricultural products are imported by the U.S. from all over the world the study includes only the major producer countries. Table 8 presents the average weight of U.S. imports from the 10 major sources, the size of the material footprint on each country and the annual change of import from each source during the research period (for data on the whole list of countries and import in specific years see appendix 1 tables 4 and 5).

Table 8 U.S. agricultural crops import from major sources and the required land inputs

	Source	Average (1995-2005)	Standard deviation	Average annual change	Average (1995-2005)	Standard deviation	Average annual change
		Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
1	**Canada**	8,954,140	806,330	+ 2.7	3,076,590	396,630	- 0.1
2	**Malaysia**	5,719,430	1,481,040	+ 8.4	542,750	77,640	+ 4.2
3	**Mexico**	4,832,600	930,520	+ 8.5	770,980	96,920	+ 0.8
4	**Brazil**	3,910,670	962,890	+ 11.1	1,037,470	184,560	+ 5.2
5	**Guatemala**	2,887,970	826,730	+ 18.6	186,450	13,820	+ 1.2
6	**Indonesia**	2,477,000	831,950	+ 12.7	1,369,120	141,470	+ 3.7
7	**Costa Rica**	2,370,460	476,600	+ 8.5	102,850	12,340	+ 2.6
8	**Dom Republic**	2,231,140	953,540	+ 6.1	189,290	62,700	- 6.1
9	**Philippines**	2,022,570	654,070	+ 3.7	57,200	10,160	- 3.2
10	**Argentina**	1,808,310	330,300	+ 3.6	206,890	54,190	+ 12.0
	Total	**37,214,310**			**7,539,600**		
	Rest of the world	**19,635,000**			**6,292,700**		

These major sources presented in table 8 represent 66% of the overall agricultural imported weight and 55% of the 'imported land'. The increasing imported weight and the equivalent required land inputs presented in the above tables are also indicating that growing different agricultural products in different countries require different land inputs (e.g. grain versus vegetables). The following paragraphs explore in detail each of the agricultural categories in their production locations around the world. It documents the imported quantities, their major sources and the footprint of each source involved with the production of the specific export products.

7.2.1.1 Fruits

The study traced fruits imported by the U.S. from 37 countries. On average the U.S. imports a total of 13,000,000 Mt of fruit per year, representing a demand on average for 778,000 ha of productive agricultural land. The general trend shows a linear relationship and an increase of imported weight as well as the area of land devoted to grow export products. The total amount of fruit imported has increased by 60 % from 10,084,000 Mt in 1995 to 16,172,600 Mt in 2005; a yearly average increase of 471,000 (chart 1). That increase in fruit imports reflects the growing role of imports in total U.S. fruit consumption, from 27.5% in 1995 to 41.4% in 2005. As shown in Chart 1 the increase of fruit imports led to an increase in the amount of land devoted to growing those fruits by 46 % from 662,450 ha in 1995 to 966,350 ha in 2005 a yearly average increase of 26,100 Ha.

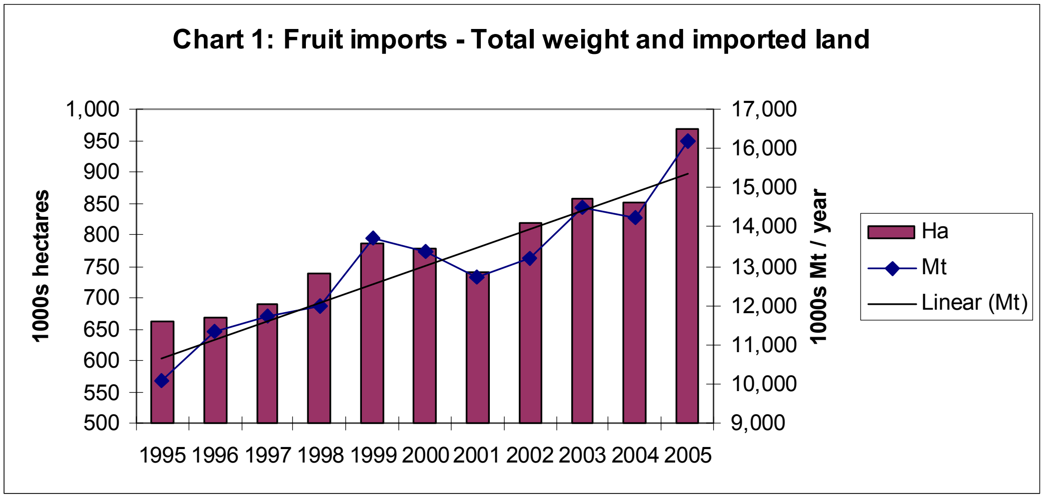


Chart 1: Fruit imports - Total weight and imported land

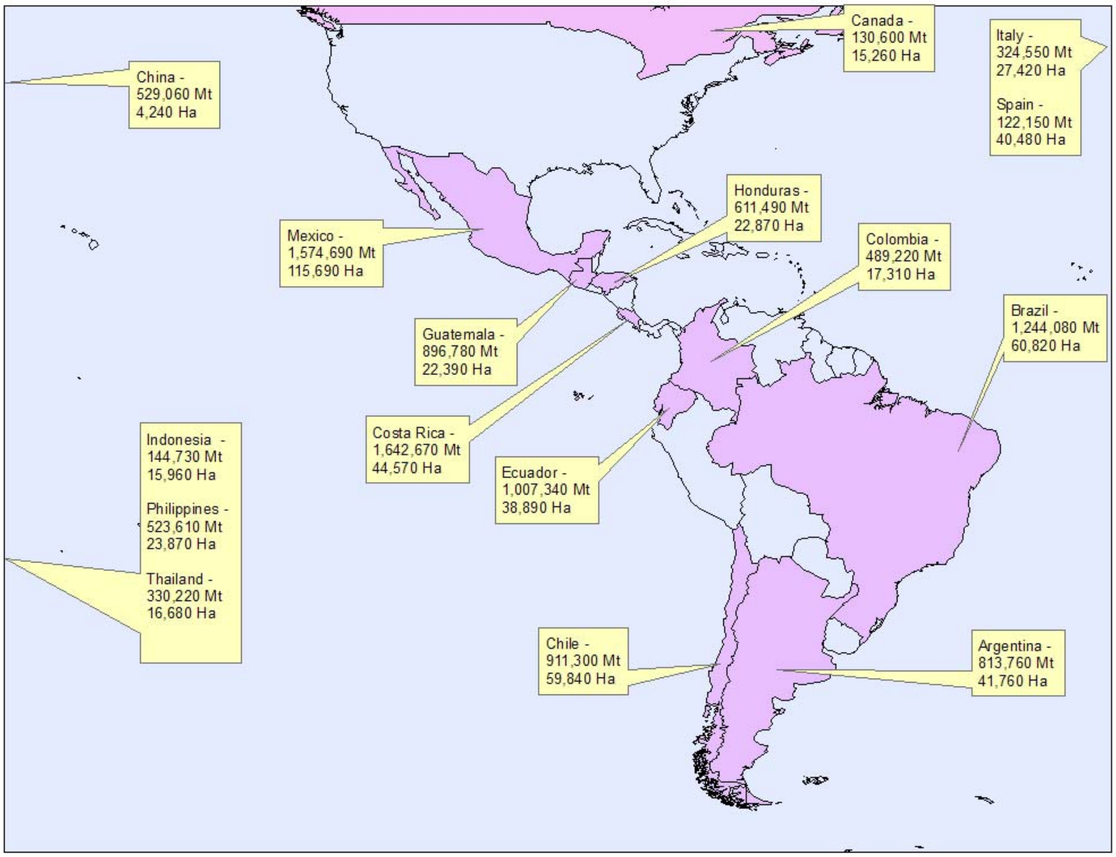
Out of the 27 fruits covered by the study, 12 comprise more than 95% of the imported weight and almost 93% of the 'imported fruit lands'. Table 9 presents these 12 major products. (For the complete fruit data see appendix 1 tables 6 and 7). It documents the average import weight and the land inputs for each fruit, the average annual change of import during the research period and the percent each fruit makes up of total fruit imported to the U.S. While it reveals an increase of each of the fruit imported the increase in the required land was smaller and in some even shows reduction. This can be explained by increase yields and changing sources.

Table 9: Major U.S. fruit imports (average weight and land) 1995- 2005

Imported Product	**% of total fruit import**	**Average annual import**	**Standard deviation**	**Average annual change**	**% of total 'fruit lands'**	**Average annual 'imported' land**	**Standard deviation**	**Average annual change**
	%	Tonnes	Tonnes	+/- %	%	Hectares	Hectares	+/ - %
Apples	15.4	2,005,920	433,220	+ 7.4	16.5	128,000	24,370	+ 5.0
Avocados	0.9	115,270	81,100	+ 27.9	2.1	16,070	9,050	+ 22.6
Bananas	30.1	3,914,040	165,970	+ 0.5	14.4	111,900	5,800	- 0.6
Coconuts	0.5	70,910	7,210	+ 3.4	2.2	17,400	1,600	+ 0.8
Grapes	11.1	1,437,920	320,730	+ 9.4	17.7	137,820	27,930	+ 7.9
Lemons	2.9	376,830	178,890	+ 25.1	3.0	23,040	11,040	+ 28.3
Mangos	1.9	245,110	56,020	+ 7.3	3.4	26,310	5,550	+ 7.7
Melons	4.8	620,790	70,070	+ 1.6	4.3	33,640	4,960	- 0.4
Olives	0.8	101,340	18,700	+ 5.3	6.0	46,550	11,090	- 0.7
Oranges	14.6	1,898,510	396,910	+ 10.1	14.5	112,580	21,830	+ 8.6
Pineapples	10.5	1,370,200	184,060	+ 3.8	7.1	54,900	5,750	+ 2.4
Watermelons	1.7	220,140	35,250	+ 7.7	1.4	10,550	1,450	+ 4.5
Total	**95.2**	**12,376,970**			**92.4**	**778,000**		

While, the U.S. imports fruits from all over the world it is only 15 countries that grow most of these fruits (86%) and where most of the 'fruit lands' are located. Map 2 presents these sources, the average imported weight and associated land inputs (For data on the whole list of countries see appendix 1 tables 8 and 9).

<u>Map 2</u>: U.S. imported fruits major sources (average weight and imported land)



7.2.1.1.1 The cases of apples and bananas

Apples and bananas are two major fruit imports to the U.S. While I traced 27 kinds of fruits, the following paragraphs will focus on these two products which together represent almost 46% of the average fruit weight imported by the U.S., and the equivalent of 31% of the 'imported lands' (For the complete data on other fruits see appendix 1 table 6 and 7).

Apples:

The import of both, fresh and processed apples (e.g., dry, canned, juice) converted back to their fresh equivalent weight, were documented. Within the study period the total fresh apples equivalent imported by the U.S. has increased by a factor of almost 2 from 1,432,380 Mt in 1995 to 2,861,580 Mt in 2005. An increasing trend was identified throughout the research period resulting with an average annual increase of 125,800 Mt.

On average 87% of the imported apples are in the form of juice, I converted the amount of juice as well as other processed apples back into their fresh equivalent – Following the U.S. import data, on average 1,500,430 Mt of apple products were imported or the equivalent of 2,005,920 Mt of fresh apples (for the complete data see appendix 1 table 10).

While the U.S. still grows most of the apples consumed within its borders, apple imports as a percentage of total consumption increased significantly during the study period, from 26% of total consumption in 1995 to 45% in 2005. Table 10 presents the average weight imported from each country and the required land inputs. It also highlights the annual average change of import and land inputs in each country. The countries included here are the major providers of apples to the United States (for the complete data see appendix 1 table 10). An extra large quantity of apples is imported from additional countries that are either not included in the study, or countries that grow so few apples that there is a good chance the apples (or the apple product) were not grown in that country but in a third one. Therefore, the 'apple lands' for this extra import were calculated based on global averages.

Another interesting fact is that within the study period a change in the trade partners made the studied countries responsible for most of the apples exported to the U.S. (e.g., China has become a major source replacing other sources).

Table 10: Quantities of apples imported and their footprints on specific source countries

Source	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
Argentina	439,590	89,750	+ 8.2	17,480	3,570	+2.3
Brazil	36,700	20,130	+ 36.6	1,240	530	+ 28.8
Canada	88,950	9,590	- 0.2	4,720	760	+ 1.0
China	495,890	498,700	+ 72.5	48,520	41,900	+ 57.5
Chile	315,880	119,870	+ 16.9	10,390	2,730	+10.7
Italy	77,530	66,620	+ 13.6	2,370	1,790	+ 9.8
Mexico	32,640	12,130	+ 6.9	4,510	2,050	+ 4.8
New Zealand	79,110	23,380	+ 9.6	2,030	610	+ 6.2
South Africa	69,920	29,080	+ 0.1	2,690	1,200	- 1.5
Turkey	38,100	22,160	+ 20.2	1,770	1,040	+ 23.6
Rest of the world	331,610	180,060	- 9.1	31,060	21,950	- 11.1
Total	**2,005,920**			**128,000**		

Bananas:

Unlike apples, bananas are hardly grown in the U.S. and are almost entirely imported. Within the study period the amount of bananas imported was steady (other than an increase in 1999-2000). On average 3,914,040 Mt of bananas were imported annually, comprised of mostly fresh bananas but also some manufactured products such as dried, frozen, and prepared (e.g., baby food). The calculation here was made without converting the manufactured bananas into a fresh equivalent due to a lack of conversion data. Therefore, the results presented here are probably slightly conservative and actual import weights may be higher. The following chapter VIII makes some of the linkages between growing bananas for export and specific ecological change in Costa Rica.

The study followed the flow of bananas imported from 17 countries, however 7 countries grow most of the bananas imported by the U.S. Table 11 presents the total and annual change of banana weight imported and the land required for production in each country (for the complete data see appendix 1 table 11).

Table 11: Quantities of bananas imported and their footprints on specific source countries

Source	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
Colombia	485,910	69,960	+ 3.2	16,940	2,510	+ 4.3
Costa Rica	1,073,350	244,910	+ 0.1	22,130	4,990	- 0.5
Ecuador	972,590	93,620	+ 0.3	35,340	4,420	+ 0.3
Guatemala	729,010	227,480	+ 10.0	16,400	2,670	+ 5.5
Honduras	434,290	155,330	+ 16.5	11,930	3,300	+ 10.2
Mexico	105,200	70,080	- 11.2	4,040	2,970	- 8.6
Rest of the world	123,610	86,100	+ 15.0	3,290	2,700	+ 21.4
Total	**3,914,040**			**110,050**		

7.2.1.2 Grains

The U.S. is one of the world's largest grain producers and exporters, but it imports various grains as well. I traced 7 kinds of grain from 37 countries, which represent the vast majority of U.S. grain imports. Grain is imported in two major forms: as raw material and processed grain products (e.g., pasta), or embodied in livestock feed. While the second group is probably significant, this study focuses only on the raw products[14] (Chart 2). On average within the research period the U.S. imported 6,041,900 Mt of grain a year. While this is just a small fraction of the total U.S. grain consumption (5.3%) it represents a large area of land in producer countries, an average of 2,409,500 ha per year, devoted to growing grain consumed in the U.S. Grain imports during the study period occupied approximately 16% of the total lands devoted to production of agricultural exports to the U.S.

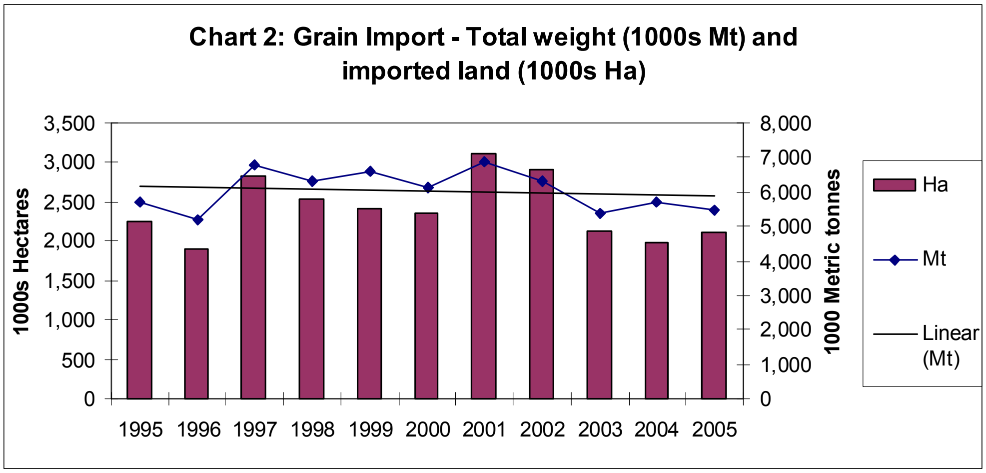


Chart 2: Grain Import - Total weight (1000s Mt) and imported land (1000s Ha)

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[14] The omission of grain imports in the form of livestock feed is due to the lack of accurate data on the components of animal feed in most countries. However, the Canadian case study (chapter IX) includes grain for animal feed.

The following table 12 presents the average weight and the required land for each of the grain crops and the annual average change of import during the research period (for the complete data see appendix1 tables 12 and 13). Canada is the main source of grain imports to the U.S., followed by countries such as Mexico, India, Italy and Thailand (for the complete data see appendix 1 tables 14 and 15).

Table 12: U.S. grain imports and external footprints (1995-2005)

Imported Product	Average annual import	Standard Deviation	Average annual change	Average annual 'imported' land	Standard Deviation	Average annual change
	Tonnes	Tonnes	+/- %	Hectares	Hectares	+ / - %
Barley	726,120	210,350	- 9.4	250,900	75,810	- 9.4
Maize	561,840	96,580	+ 3.1	98,290	15,410	+ 3.3
Millet	1,410	934	+ 24.4	950	390	+ 20.4
Oats	1,740,780	202,650	+ 3.2	748,070	117,760	+ 4.2
Rice	537,500	119,200	+ 7.2	192,600	32,150	+ 5.7
Rye	113,460	26,470	+7.3	53,230	11,890	+ 5.1
Wheat	2,360,800	443,370	+ 2.0	1,065,450	263,900	+ 2.9
Total	**6,041,910**			**2,409,490**		

7.2.1.3 Legumes

I traced the sources of 4 groups of legumes (beans, chickpeas, lentils and peas) imported from 32 countries. Within the research period the U.S. imported a yearly average of 298,050 Mt of legumes. Although this amount is relatively insignificant compared to other agricultural imports (0.5 % of the total weight of imported agricultural products and 1.1% of total lands), it is interesting that imports of legumes increased steadily throughout the study period. The general trend shows a constant linear increase of imported weight (R_2 = 0.94) as well as the area of land (R_2 = 0.90) devoted to grow legumes for export. The total amount of legumes imported has increased by 142 % from 179,200 Mt in 1995 to 433,600 Mt in 2005; a yearly average increase of 30,760 (chart 3). At the same time legume land inputs in the supporting countries increased by 157%, from 97,880 ha to 251,720, a yearly average increase of 19,060 ha.

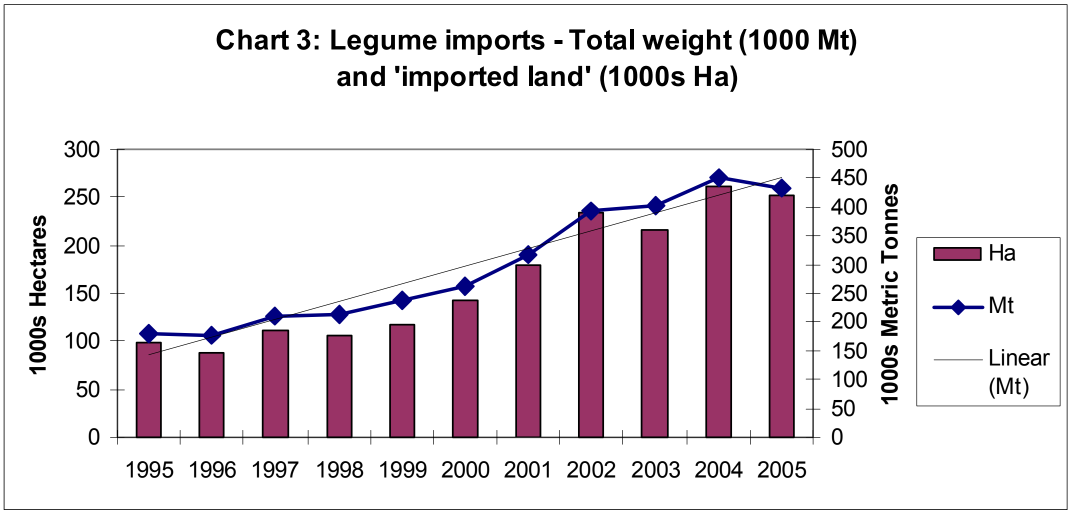


Chart 3: Legume imports - Total weight (1000 Mt) and 'imported land' (1000s Ha)

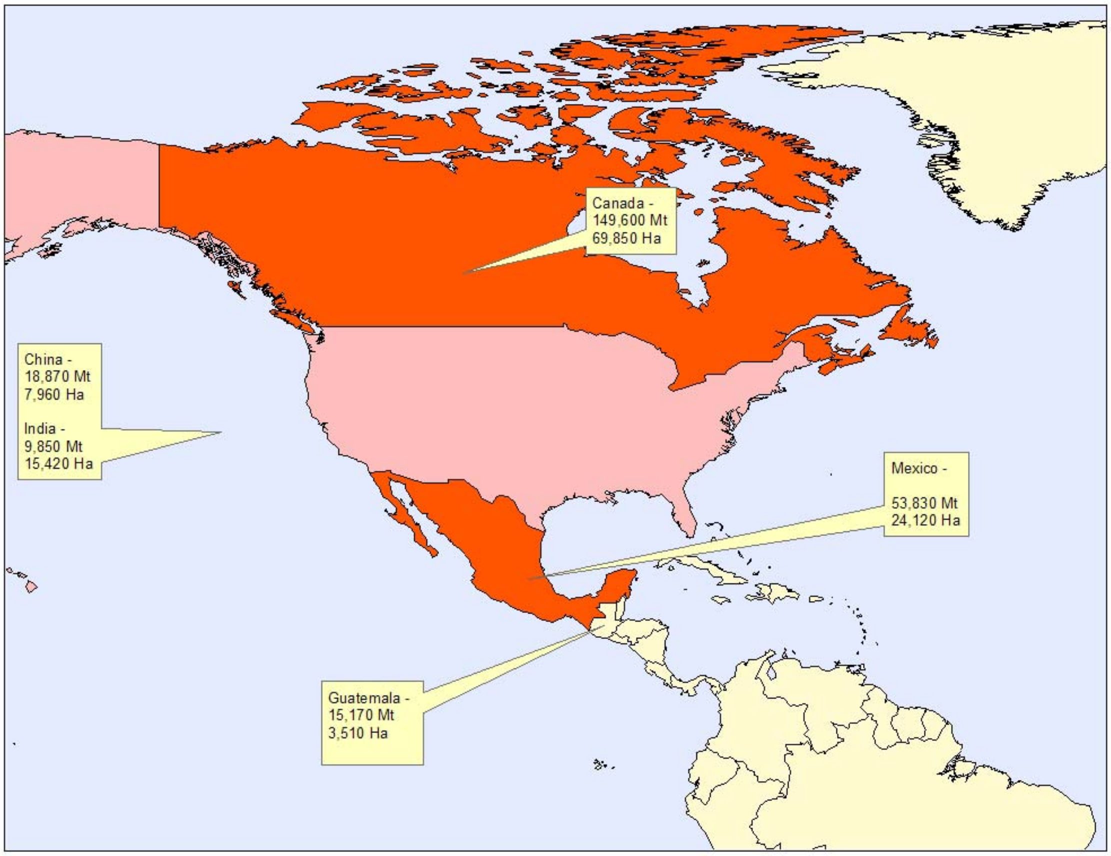
Table 13 presents the weight and the land inputs for each of the legumes at the beginning and at the end of the research period. It also presents the average annual import weight of each crop, and the part each grain makes up of total U.S. legumes imports (for the complete data see appendix 1 tables 16 and 17).

Table 13: U.S. legume imports and their external footprints (1995-2005)

Imported Product	**Average annual import**	**Standard deviation**	**Average annual change**	**Average annual 'imported' land**	**Standard deviation**	**Average annual change**
	Tonnes	**Tonnes**	**+/- %**	**Hectares**	**Hectares**	**+/- %**
Beans	179,070	84,500	+ 13.0	105,660	56,340	+ 15.0
Chickpeas	15,460	2,080	+ 5.1	12,110	1,990	+ 5.6
Lentils	11,430	3,660	+ 15.3	11,850	3,820	+15.4
Peas	92,090	19,120	+ 5.7	34,610	6,120	+ 4.5
Total	**298,050**			**164,230**		

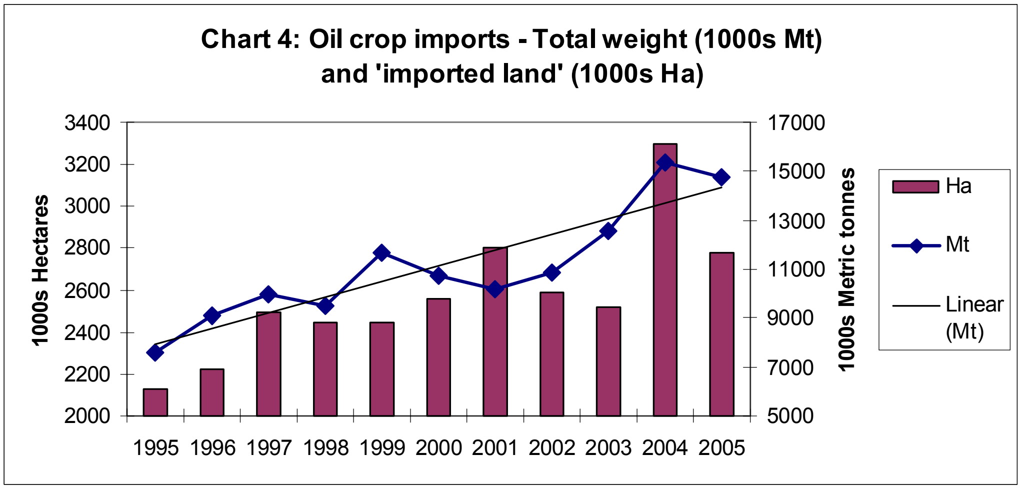
While the U.S. imports legumes from all over the world, on average about 73% of the imports come from Canada and Mexico. Other major sources are China (6.8%), Guatemala (5.5%), and India (3.5%). Map 3 presents the average weight and devoted land in major source countries of U.S. Legume imports (for the complete data see appendix 1 tables 18 and 19).

Map 3: U.S. imported legumes major sources (average weight and imported land)



7.2.1.4 Oil Crops

I documented the flow of 10 oil crops originating in 38 countries. Oil crops are imported as raw materials and as processed oils. I include the data on raw crop imports and convert oil imports to their crop weight equivalent. Altogether on average, the U.S. imported 11,126,500 Mt of oil crops annually. To grow / produce that amount an average of 2,570,170 ha around the world was required on an annual basis. The general trend shows a constant linear increase of imported weight (R2 = 0.80) as well as the area of land (R2 = 0.61) devoted to grow oil crops for export. Within the study period a significant increase of 94 % in the amount of oil crops imported was identified from 7,612,040 Mt in 1995 to 14,744,060 Mt in 2005, an average yearly increase of 636,500 Mt. At the same time the land devoted to growing these products has increased by 30% at a yearly average change of 75,100 ha (Chart 4).



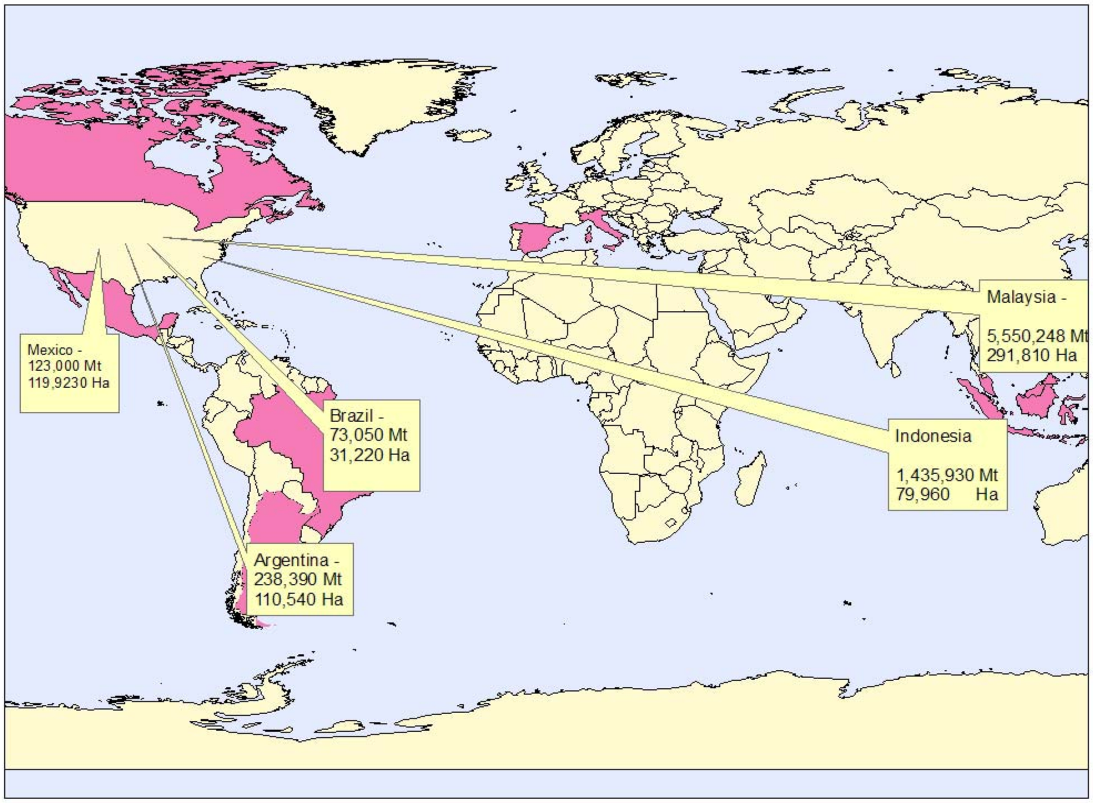
Soy bean is the major oil crop consumed in the U.S. and much of it is grown locally. U.S. consumption of other oil crops, however, is dependant upon imports. Table 14 presents the change in weight and land inputs for each of the oil crops between the beginning and the end of the research period. It also presents the average annual import weight of each crop, and the part each crop makes up of total oil crops imported to the U.S. (for the complete data see appendix 1 table 20 and 21). The three major oil crops imported by weight and required land inputs are Palm oil, olives and rapeseed.

Table 14: U.S. oil crop imports and their external footprints (1995-2005)

Imported Product	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
Flaxseeds	154,580	55,410	+ 4.3	127,650	37,150	+ 4.1
Ground Nuts	335,640	140,930	+ 22.8	188,300	97,640	+ 30.1
Mustard	84,100	11,750	+ 1.3	99,000	18,640	+ 2.8
Olives	1,198,800	298,350	+ 8.5	479,520	70,120	+ 3.5
Palm	7,475,870	1,853,590	+ 9.2	415,200	90,210	+7.8
Rapeseeds	1,141,120	125,930	+ 3.7	798,720	64,130	+ 0.3
Safflower	44,480	11,180	+ 10.9	30,630	9,500	+ 7.3
Sesame	58,960	6,140	+ 2.7	135,490	15,010	+ 4.0
Soy beans	435,480	246,540	+ 23.4	187,090	112,390	+ 27.4
Sunflower	121,140	48,370	+ 12.4	108,570	47,490	+ 16.6
Total	**11,126,500**			**2,570,170**		

As in the case of other agricultural products, while the U.S. imports oil crops from all over the world, 9 countries are the major suppliers of more than 97% of oil crop imports and 92% of the associated lands around the world. Map 4 presents some of the major sources of oil crop imports (for the complete data see appendix 1 tables 22 and 23).

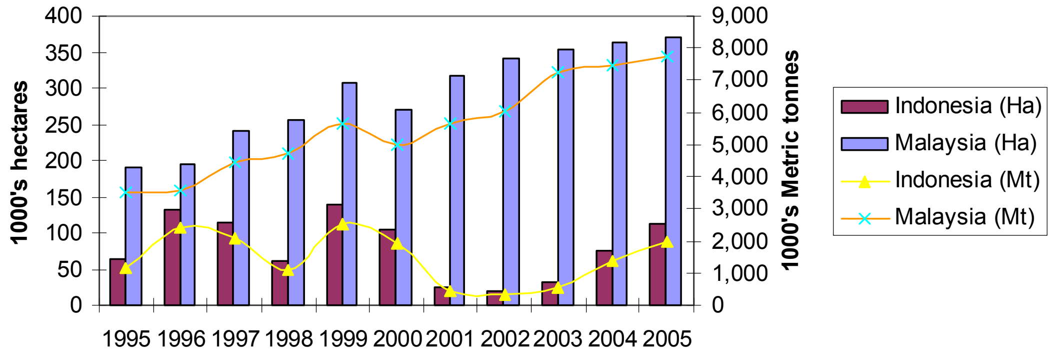
Map 4: U.S. oil crops major sources (average weight and imported land)



7.2.1.4.1 The case of palm oil

Of the overall oil crops imported to the United States within the study period, palm oil has a significant place, accounting for 67.3% of total oil crops imported and 16.2% of the "imported" oil crop lands. The U.S. does not grow palm fruit at all; it relies entirely on imports of that product, mostly in the form of oil. Within the study period palm oil imports increased significantly and while the palm fruit equivalent in 1995 was 4,980,450 Mt; in 2005 it more than doubled to 10,593,660 Mt, an average yearly increase of 489,410 Mt. That increase in imports meant an increase in the amount of land inputs from 282,960 ha in 1995 to 415,200 ha in 2005. Palm fruit and its products are imported by the U.S. from 14 countries. Two countries - Malaysia and Indonesia - are the major sources and recorded most of the export increase. Chart 5 presents the change in exported palm equivalent and in the required land within the study period in these two major palm oil sources.

Chart 5: Change in palm import and the equivalent of U.S palm oil lands in Indonesia and Malaysia



7.2.1.5 Stimulants

While the U.S. grows most of its sugar crops, cocoa tea and coffee are entirely imported. I identified 48 countries that exporting stimulants to the U.S. Most often stimulants are consumed in processed form; for the calculations of import weight and land inputs I converted each product back to its raw stage: coffee to green beans, sugar to sugar cane and so on. Altogether within the research period these products were imported at average rates of 2,193,000 Mt a year, requiring 3,307,400 ha of land to grow them. Table 16 presents the imports of each product and the amount of overseas land devoted to growing these products; both increased during the study period (for the complete data see appendix 1 tables 24 and 25). Table 15 also emphasizes that while sugar is the main stimulant imported by weight (88.5%) it required only a relatively small proportion of the 'imported' lands devoted to stimulants (7.8%).

Table 15: U.S. stimulant imports and their external footprints (1995-2005)

Imported Product	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
Cocoa	761,160	117,680	+ 6.8	1,600,710	157,520	+ 3.0
Coffee	1,160,580	98,150	+ 2.8	1,634,730	134,930	- 0.5
Sugar	16,927,370	5,309,880	+ 6.8	278,520	98,570	+ 3.8
Tea	88,150	5,960	+ 2.2	72,010	3,610	- 0.6
Total	**18,937,270**			**3,585,970**		

Stimulants are imported to the United States from a large number of sources around the world. Table 16 presents the major sources, as well as average import weights and required land for stimulant production in each country (for the whole data see appendix 1 tables 27 and 28).

Table 16: U.S. stimulants import from major sources and the required land inputs (1995-2005)

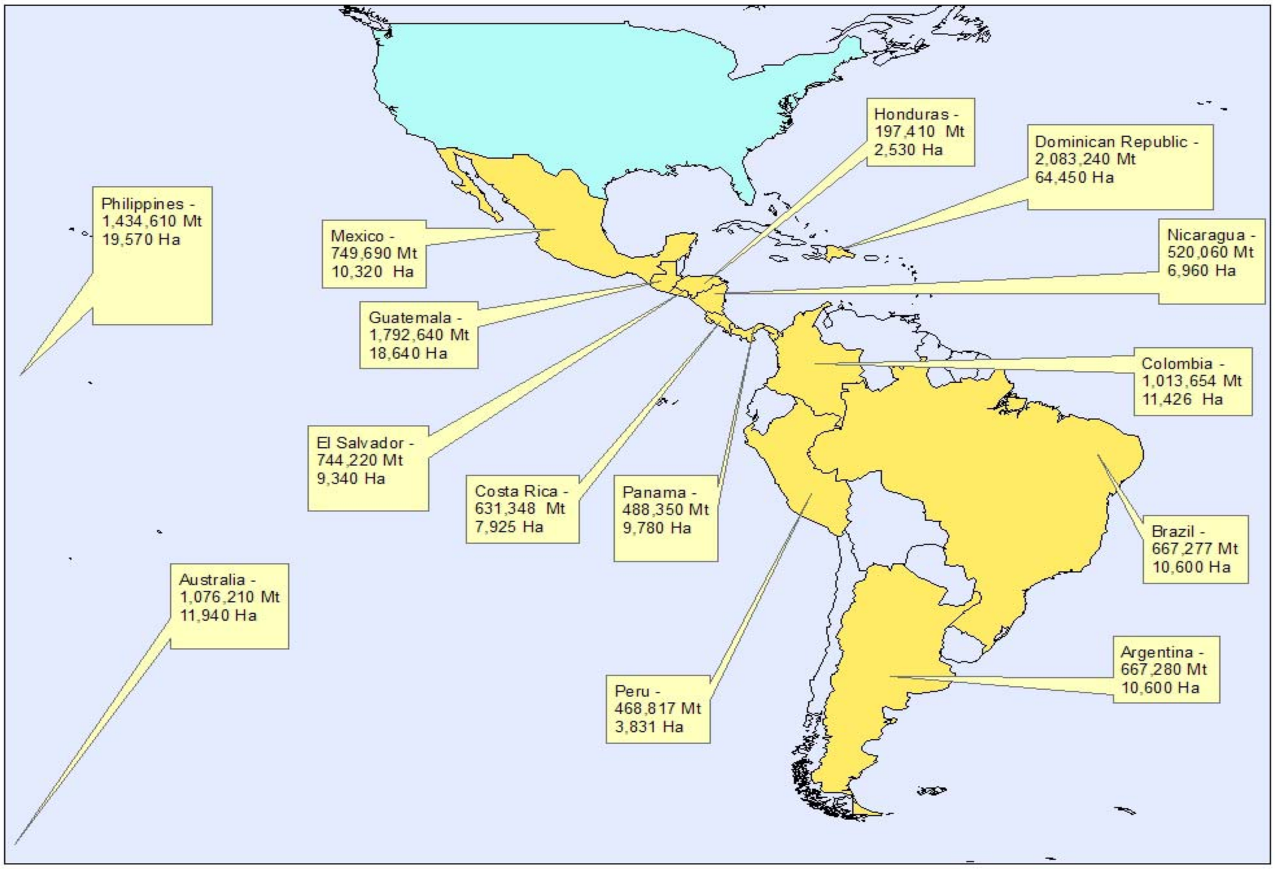
Source	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
Brazil	2,364,200	845,350	+ 14.5	450,910	91,470	+ 4.9
Dominican Republic	2,122,800	953,850	+ 6.5	171,650	61,620	- 6.4
Guatemala	1,904,320	871,980	+ 34.7	134,650	13,790	+ 2.2
Philippines	1,437,450	681,450	+ 7.0	25,130	10,900	- 2.6
Columbia	1,220,750	396,540	+ 2.5	229,330	39,220	+4.2
Australia	1,076,200	500,920	+ 3.8	11,940	4,660	+ 4.5
Total	**10,125,720**			**1,023,610**		

7.2.1.5.1 The case of sugar

In terms of the weight of the sugar cane required for sugar production, sugar is the most dominant single commodity imported by the U.S. On average within the study period the U.S. imported 16,927,370 Mt a year. Most of the sugar consumed in the U.S. is produced from locally grown sugar cane and beets. Still, during the study period an average of 23% of total sugar consumption was imported. Most sugar imported by the U.S. is imported as raw sugar.

I traced sugar imported from 32 countries. Map 5 presents the major sources of U.S. sugar imports. It shows the average sugar cane equivalent weight and the average required lands (for the whole data see appendix 1 table 28).

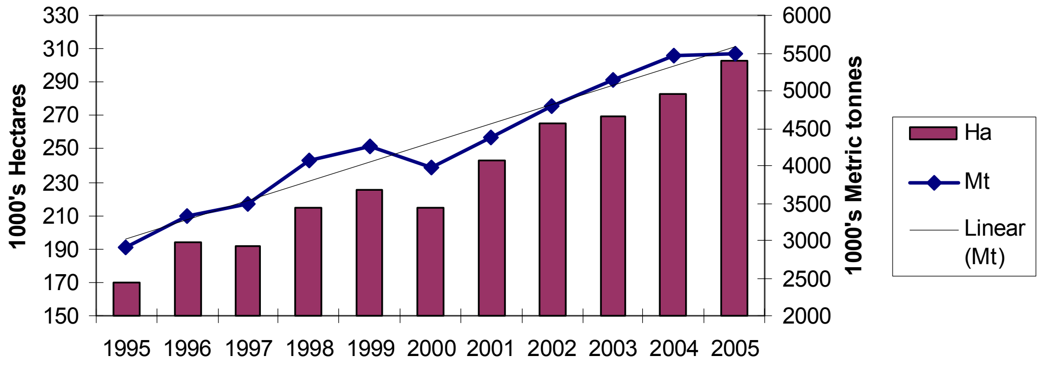
<u>Map 5</u>: U.S. imported sugar major sources (average weight and imported land)



7.2.1.6 Vegetables

I documented the flow of 19 kinds of vegetables imported from 33 countries. In terms of weight, vegetables represent 10% of total agricultural product imports to the U.S. On average 4,296,700 Mt annually were imported within the study period. The general trend shows a constant linear increase of imported weight (R_2 = 0.96) as well as the area of land (R_2 = 0.96) devoted to grow vegetables for export. Vegetable imports increased from 2,907,250 Mt in 1995 to 5,487,470 Mt in 2005, an increase by a factor of 1.9 or a yearly average increase of 254,870 Mt (Chart 6). Compared to other agricultural products, vegetables represent a smaller land requirement. The study shows that only 2% of the ‘imported’ lands were devoted to growing vegetables. However, even here we see a significant change in the amount of land required for growing imported vegetables, from 169,900 ha in 1995 to 302,900 ha in 2005. This represents an increase by a factor of 1.8, a yearly average increase of 12,500 ha (Table 16).

Chart 6: Vegetable imports - Total weight (1000's Mt) and 'imported land' (1000's Ha)



While most vegetables are imported fresh, some are imported after processing (e.g., ketchup, fries, etc.). The results presented here are the fresh equivalents of each product. Of the 19 vegetables included in the study, 10 comprise more than 90% of the imported weight and of the ‘vegetable imported lands’. Table 17 presents each of these products. It presents the average import of each vegetable in terms of weight and the required land, the annual change within the study period, and the part each vegetable makes up of total U.S. vegetable imports. (for the complete data see appendix 1 tables 29 and 30).

Table 17: U.S. vegetable imports and their external footprints (1995-2005)

Imported Product	% of vegetable imports	Average annual import	Standard Deviation	Average annual change	% of total lands	Average annual 'imported' land	Standard Deviation	Average annual change
	%	Tonnes	Tonnes	+ / - %	%	Hectares	Hectares	+ / - %
Asparagus	1.7	75,110	29,870	+ 12.9	6.0	13,930	3,140	+ 8.3
Broccoli	6.7	288,750	39,060	+ 4.0	10.4	24,270	3,450	+ 3.8
Cabbages	1.0	41,040	6,020	+ 5.2	0.8	1,840	280	+ 5.3
Carrots	2.4	103,130	9,310	+ 0.7	1.5	3,430	330	+ 0.7
Cucumbers	9.0	386,920	63,360	+ 5.9	6.9	16,080	3,770	+ 10.0
Lettuce	1.0	41,200	19,300	+ 14.4	0.8	1,870	870	+ 12.9
Onions	6.4	273,210	34,250	+ 4.8	7.9	18,480	1,590	+ 2.1
Potatoes	25.8	2,754,050	1,110,530	+ 15.2	15.1	109,330	49,740	+ 16.7
Peppers	10.3	442,750	112,880	+ 9.1	26.2	61,300	14,690	+ 34.4
Tomatoes	26.5	1,137,610	146,720	+ 4.2	14.7	34,390	3,050	- 0.4
Total	**90.7**	**5,543,790**			**90.1**	**284,900**		

Most vegetables imported by the U.S. come from Canada (42%) and Mexico (34%). These two major sources are followed by other exporters such as: China, Guatemala, Honduras, and Chile. Approximately 15% of average annual U.S. vegetable imports are not included in the study; in some cases the vegetables originate in countries that are not included in this study and in other cases products could not accurately be traced to their original sources (for the complete data see appendix 1 tables 31 and 32).

7.2.1.6.1 The case of potatoes and tomatoes

While both potatoes and tomatoes are grown in the U.S. for local consumption and for export, within the study period imports of these vegetables as both fresh and processed products increased. As presented in the above Table 17, they make up the majority of total U.S. vegetable imports by weight. Together they represent 52% of average vegetable imports by weight and the equivalent of almost 30% of the 'imported lands' (for the complete data on other vegetables see appendix 1 tables 29 and 30).

Potatoes:

I documented the import of fresh potatoes as well as processed potato products converted back to their fresh equivalent weights[15]. Within the study period the total fresh potato equivalents imported by the U.S. increased by a factor of 3.2 from 473,100 Mt in 1995 to 1,544,600 Mt in 2005, an average annual increase of 117,500 Mt. (see appendix 1 table 33). Most of the potatoes imported by the U.S. are processed potatoes; of these, French fries represent the majority. While

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[15] For the lack of data I did not include such products as potatoes flour, and potatoes chips.

most of the potatoes consumed in the U.S. are still grown locally, potato imports as a proportion of total consumption have increased from only 2.5% of consumption in 1995 to 8.6 in 2005. Canada is almost the only foreign source of potatoes for the U.S. Within the research period a yearly average of 1,101,560 Mt of potatoes were imported from Canada. That import represents 98% of total potato imports.

Tomatoes:

I documented the import of fresh tomatoes as well as processed products converted back to their fresh equivalent weights. Within the study period the total fresh tomato equivalents imported by the U.S. increased by a factor of 1.4 from 887,300 Mt in 1995 to 1,252,400 Mt in 2005, an average yearly increase of 32,000 Mt. During the same time the required land decreased as a result of increases in production per hectare (yields). In 1995, 33,250 ha were required to grow the total tomato imports while in 2005 that amount of land decreased to 31,650 ha (for the complete data see appendix 1 table 34).

Although tomatoes are imported from 18 countries only 5 are major sources of that import. Unlike the case of potatoes where most of the imports were processed products, most tomatoes are imported fresh. Mexico is the primary source followed by Canada and then Italy, Israel and Chile. Table 18 presents the weight of exports and the land inputs in each source country.

Table 18: Quantities of imported tomatoes and their footprints on source countries (1995-2005)

Source	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	Tonnes	+ / - %	Hectares	Hectares	+ / - %
Canada	221,380	87,890	+ 13.8	2,690	730	+ 7.8
Chile	9,160	6,640	+ 81.7	140	110	+ 3.3
Israel	29,360	15,480	- 0.2	300	170	- 4.4
Italy	33,620	28,740	- 4.0	670	590	- 5.0
Mexico	746,780	74,130	+ 3.2	26,850	2,670	- 0.7
Total	**1,040,290**			**30,650**		

7.2.1.7 Fibers

The U.S. is a major producer of agricultural fibers such as cotton and tobacco however it also imports large quantities as raw materials and as processed industrial products. I documented 6 kinds of fiber imported from 42 countries. As presented and discussed in the research method chapter (chapter VI), tracing the sources of industrial products (e.g., cotton shirt, tobacco in cigarettes) is sometimes an impossible task. Some countries grow the raw material, export it to another country where the final product is manufactured and then export it to a third country where it is consumed. The current study included only those countries and amounts of agricultural fibers for which I could assume with a high probability of accuracy that the exporting country is also the producer. Most fibers included in the study are in raw material form and I have included some industrial products such as cotton and jute products. The study does not include products such as tobacco in cigarettes, or natural rubber in tires. Therefore, the results presented here, significant as they are, include only a portion of the agricultural fibers in terms of weight and the land imported by the U.S.

Within the study period the total amount of agricultural fiber products imported by the U.S. has constantly increased; the general trend shows a linear increase of imported weight (R2 = 0.93) as well as the area of land (R2 = 0.88) devoted to grow vegetables for export. In 1995 the U.S. imported 2,025,200 Mt, in 2005 the imported weight got to 3,294,700 Mt, an increase by a factor of 1.6 or a yearly average increase of 138,150 Mt (Chart 7). The study shows a significant change in terms of required land inputs as well, from 2,784,600 ha in 1995 to 4,373,500 ha in 2005, an increase by a factor of 1.6 or a yearly average increase of 169,900 ha (Chart 7).

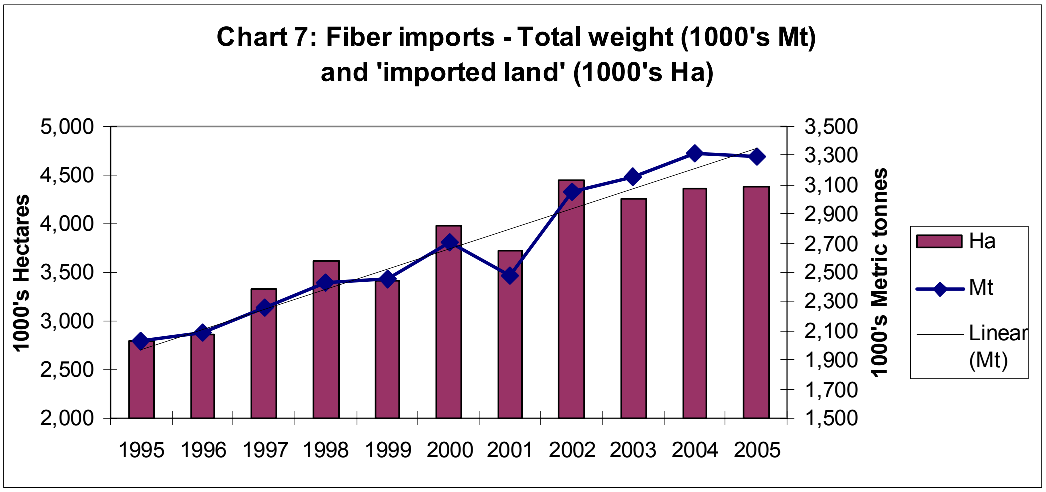
Chart 7: Fiber imports - Total weight (1000's Mt) and 'imported land' (1000's Ha)

While I documented agricultural fiber flows from 42 countries it is the imports from 10 that account for 93% of the imported weight and almost 96% of the required lands (appendix 1 tables 35 and 36).

Table 19 presents each of the fibers included in the study, at the beginning and at the end of the research period, in terms of weight and land inputs. It also presents average annual imports of each crop, and the part each crop makes up of total fiber imports (appendix 1 tables 37 and 38 present the major sources of fibers imported into the U.S.).

Table 19: U.S. fiber imports and their external footprints (1995-2005)

Imported Product	**% of Fiber imports**	**Average annual import**	**Standard Deviation**	**Average annual change**	**% of total lands**	**Average annual 'imported land'**	**Standard Deviation**	**Average annual change**
	%	**Tonnes**	**Tonnes**	**+ / - %**	**%**	**Hectares**	**Hectares**	**+ / - %**
Cassava	3.0	80,480	18,580	+ 7.3	0.1	5,340	1,050	+ 6.1
Cotton	42.3	1,124,170	420,250	+ 11.4	56.2	2,103,050	553,580	+8.7
Jute	1.2	30,780	6,300	- 1.8	0.4	15,700	4,090	- 1.8
Rubber	42.2	1,123,320	77,950	+ 1.7	36.9	1,381,910	99,940	+ 1.9
Sisal	2.0	53,760	15,940	- 2.8	1.6	60,010	18,980	- 4.4
Tobacco	9.3	246,710	36,190	+ 3.9	4.7	174,840	30,450	+ 7.7
Total	**100**	**2,659,220**			**100**	**3,740,830**		

7.2.1.7.1 The case of cotton

The calculation procedure for the flow of cotton products and raw cotton equivalents has been discussed in detail in Chapter VI. As explained, the cotton included in the study captured only about 30% of the cotton flows in the U.S. Still it presents a significant amount in terms of both the imported weight and required land inputs in the source countries. On average within the study period the yearly raw cotton equivalent imported by the U.S. was 1,065,000 Mt, which required a yearly average of 2,050,800 ha of land around the world. The increase of cotton product imports within the study period is one of the most significant changes in this study; the weight equivalent has increased by a factor of 2.8, from 603,150 Mt in 1995 to 1,715,500 Mt in 2005 and the land inputs by a factor of 2.1 from 1,208,700 ha in 1995 to 2,625,600 ha in 2005.

Of the studied countries 4 comprise about 89% of the average cotton equivalent weight imported by the U.S. Table 20 presents the imports from each country and the amount of land inputs needed in each for growing cotton consumed in the U.S. (for the complete data see appendix 1 table 39).

Table 20: Quantities of cotton imports and their footprints on source countries (1995-2005)

Source	Average annual import	Standard deviation	Average annual change	Average annual 'imported' land	Standard deviation	Average annual change
	Tonnes	**Tonnes**	**+ / - %**	**Hectares**	**Hectares**	**+ / - %**
China	322,190	176,460	+ 15.7	307,580	159,770	+ 13.4
India	229,800	54,380	+ 8.5	987,140	233,640	+ 8.6
Pakistan	374,120	161,210	+ 16.6	600,920	214,190	+ 15.0
Turkey	79,500	24,640	+ 7.2	62,150	17,960	+ 5.4
Rest of the studied sources	118,850	17,960	+ 5.4	145,260	36,750	+ 3.8
Total studied countries	1,124,170	420,250	+ 11.4	2,103,050	553,580	+ 8.7
Rest of the world[16]	2,055,340	519,930	+ 8.7	3,321,750	693,490	+ 6.1
Total	3,120,370	898,110	+ 10.1	5,372,550	1,225,120	+ 7.3

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[16] Part of that might be cotton grown in the U.S. and therefore it is not included in the study.

7.2.2 Meat Products

Of the meat products consumed in the U.S., I focus on beef and lamb products and live cattle imports. Although the U.S. is a major meat producer and exporter, close examination reveals that a growing proportion of meat consumed within the U.S. is imported. For example, in 1995 8% of the beef consumed in the U.S. was imported, while in 2005 13% was imported. In the case of lamb the change is even greater from 19% of consumption in 1995 to 50% in 2005. On average in the research period the U.S. has annually imported 1,338,500 Mt of beef, 53,170 Mt of lamb, and 2,078,500 live cattle. Altogether the equivalent of 7,699,900 head of cattle and 2,772,400 head of sheep were imported to the U.S. annually. Table 21 presents the different sources of imported beef products, the average imported weight, the equivalent live cattle required, and the area of land devoted to meat production in each source country.

Table 21: Quantities of imported meat, required livestock and pasture land

Exporting country	Average annual meat import by the U.S.	Animal head equivalent[17]	% of total meat import	Pasture land required
	Mt	No	%	Ha
Argentina	51,900	241,800	2.3	1,947,000
Australia	465,100	3,686,200	34.3	23,645,000
Brazil	66,200	312,200	2.9	1,910,100
Canada	402,200	2,280,000	21.2	7,214,500
Costa Rica	16,600	75,400	0.7	475,300
Honduras	2,900	17,600	0.2	70,200
Mexico	7,900	1,081,700	10.1	11,067,900
New Zealand	298,400	2,661,800	24.8	1,002,500
Nicaragua	19,700	128,200	1.2	1,466,500
Uruguay	60,800	257,400	2.4	1,920,600
Total	**1,391,600**	**10,742,100**	**100**	**50,719,500**

Meat imports increased from 986,600 Mt in 1995 to 1,743,100 Mt in 2005 (for the complete data see appendix 1 tables 40 and 41). In terms of weight beef imports are small compared to several other agricultural products discussed in this chapter, however, the land area required to grow the livestock is larger than the overall land required for imported crops[18]. In 1995 47,988,200 ha of land were required to produce the American meat imports; by 2005 this figure had increased to 61,144,150 ha (for the complete data see appendix 1 table 42).

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[17] Including number of live cattle imported from Canada and Mexico.

[18] Chapter V discusses in detail the calculation procedure for estimating the required pasture land.

7.2.3 Wood products

I documented the U.S. imports of major wood products by weight and converted them back to their roundwood equivalents (M3). Table 22 presents the average imported weight and the roundwood equivalents.

Table 22: Major Wood product imports by average weight and roundwood equivalents

	Metric Tonnes (air dry weight)	**M3 (roundwood equivalent)**
Lumber	17,613,800	80,217,900
Plywood and veneer	1,534,900	4,029,600
Pulp wood	20,020,800	38,384,500
Logs	632,000	1,306,900
Total	**39,801,500**	**123,938,900**

Overall the U.S. import of wood products has increased significantly within the research period from the equivalent of 110,725,000 M3 in 1995 to 160,842,000 M3 in 2005, an annual average increase of 3.8%. Table 23 presents the import of different wood products at the beginning and at the end of the research period (for the complete data see appendix 1table 43).

Table 23: The change in U.S. wood import

Imported Product	**1995**	**2005**	**Average annual import**	**% of import**
	M3	**M3**	**M3**	**%**
Lumber	72,065,000	104,339,000	80,217,900	64.7
Plywood and veneer	3,035,000	12,636,000	4,029,600	3.3
Pulp wood	35,261,000	40,632,000	38,384,500	31.0
Logs	364,000	3,235,000	1,306,900	1.1
Total	**110,725,000**	**160,842,000**	**123,938,900**	

The main source of wood products imported by the U.S. is Canada (80%) followed by countries like Brazil, Chile, Indonesia, and Malaysia. As explained in the research method chapter I focused on Canada because of the lack of accurate data on productive forest areas in most export countries, therefore the forest area presented here is only part of a larger area devoted to the U.S. On average a forest area of 81,204,000 ha was devoted to producing wood products exported to the U.S. In the research period the size of that area increased from 74,671,000 ha in 1995 to 87,893,000 ha in 2005 (for the complete data see appendix 1table 44).

7.3 Summary

In this chapter I took the first steps in documenting the interregional connections of the United States, focusing on the import dimension. In order to highlight the U.S. external material linkages with the rest of the world I traced the sources and documented the major flows of renewable resources. I then quantified and located their external ecological footprints. The chapter reveals that on average within the research period the U.S. had an external material footprint of 146,729,000 Ha, an area of land equivalent to the size of Germany, Italy, Spain, Switzerland, and the United Kingdom combined. Most of that area of terrestrial ecosystem is forest followed by pasture land and cropland. On average the area of land devoted to U.S. import of forest products is 81,204,000 Ha; for meat 50,720,000 Ha; and for agriculture crops 14,805,000 Ha.

The following table 24 summarizes the average (1995-2005) composition of the U.S. external material footprint on specific sectors in each country studied here (for detailed data see appendix 1). The largest U.S. external footprint is on Canada followed by Australia, Mexico, New Zealand, Brazil and Argentina. While the U.S. imports several commodities from these countries, it is the import of meat (i.e. pastureland) that is a major component of the U.S. footprint on each country. Out of agricultural commodities imported to the U.S. the largest footprints are of wheat, oat, rapeseed, coffee, cocoa, cotton and natural rubber.

I see the results of this chapter as only the first step in quantifying the interregional connections of the U.S. I am aware that to make more explicit connections between import for consumption in one country and ecological degradation in another other physical inputs need to be quantified and connection to specific processes should be made. However, the detailed approach taken here allows a focus on specific components of trade flows and their external footprints; it identifies the sources of specific commodities and the size of their footprints as well as the overall area of land ‘imported’ from specific sources.

The results presented in this chapter reveal an increase of the U.S. import, increasing its external material footprint. Overall forest product imports have annually increased by an average of 3.8% (an increase of 45.3% from 1995 to 2005). Meat import has annually increased by an average of 6.2% (an increase of 76.6% from 1995 to 2005). Agricultural crops imports have annually increased by an average of 4.8% (an increase of 51.3% from 1995 to 2005). That increase of import led to an annual average increase of 2.3% (an increase of 23.5% from 1995 to 2005) in the overall size of the external material footprint.

While the U.S. produces most of its renewable resource needs and is also a major exporter of renewable resources the results of this chapter reveal an increasing reliance on overseas resources for each of the aggregated groups studied here. On average the U.S. imports 26% of its annual forest products consumption (increasing from 23% in 1995 to 30% in 2005); 12% of meat (increasing from 9% in 1995 to 16% in 2005); and 12% of agricultural products consumption[19]. Moreover a closer look at specific agricultural products, as taken in this chapter, reveals that some products are mostly or even entirely imported.

Following the interregional approach, these results highlight the U.S. interregional dependence on terrestrial ecosystems in specific countries and on the ecological goods exported from those countries. While the U.S. still produces many of the products documented here, a constant increase in imports emphasizes the importance of taking interregional dependence into consideration in policy and planning. The need to account for interregional connections becomes even more relevant given that local and global ecological changes might risk future flows of import materials. Moreover, quantifying the area of terrestrial ecosystem devoted to export / import in specific countries identifies a potential pressure on ecosystems in those supporting regions. As documented here the extent of U.S. import in terms of weight and required area of land is large and likely exerts pressure on supporting ecosystems in exporting countries. Furthermore, the results of this chapter highlight specific regions in which the U.S. has interregional ecological interests. The detailed approach taken here documents some of the interregional material linkages, emphasizes the need to take action toward reducing potential and actual impact of those linkages.

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[19] USDA (2003; 2005) data combined with the results presented here, show that the import of agricultural crops out of overall consumption has increased from 8% in the 1980s to 12% in the research period.

Table 24: Summary of the average U.S. external material footprint composition (hectares)

Source/Ha	Fruits	Grain	Legumes	Oil Crops	Nuts	Stimulants	Vegetables	Fibers	Pasture	Total
Argentina	41,760	6,100	820	110,530	0	33,640	840	13,200	1,958,520	**2,165,410**
Australia	10,700	5,250	2,460	2,580	0	11,940	10	5,790	4,236,920	**4,275,650**
Bahamas	1,090	0	0	0	0	0	0	0	0	**1,090**
Belize	8,590	0	80	0	0	4,880	20	0	0	**13,570**
Bolivia	10	0	80	3,940	18,270	3,010	0	0	0	**25,310**
Brazil	60,820	420	330		369,950	450,900	400	123,430	1,910,290	**2,947,760**
Burundi	0	0	0	0	0	5,040	0	0	0	**5,040**
Cameroon	0	0	0	0	0	9,970	0	6,600	0	**16,570**
Canada	15,260	1,755,780	69,850	1,158,000	0	0	74,710	2,990	6,249,440	**9,326,031**
China	4,240	11,130	7,960	16,780	2,570	23,390	4,140	307,590	0	**377,800**
Chile	59,840	3,530	450	940	0	0	2,690	0	0	**67,450**
Columbia	17,300	450	140	770	0	229,330	520	500	0	**249,010**
Congo	0	0	0	0	0	1,620	0	0	0	**1,620**
Costa Rica	44,570	10	130	0	0	54,950	320	2,870	476,600	**579,450**
Dom Republic	9,530	500	860	0	0	171,650	2,070	4,680	210	**189,500**
Ecuador	38,890	60	3,600	0	0	224,290	420	530	0	**267,790**
Egypt	0	90	0	20	0	0	0	79,400	0	**79,510**
El Salvador	150	180	2,300	1,440	40	57,680	210	0	0	**62,000**
Ethiopia	0	50	380	4,260	0	8,710	30	0	0	**13,430**
Ghana	0	0	0	550	0	79,660	0	580	0	**80,790**
Greece	4,320	1,310	0	8,740	0	0	50	5,100	0	**19,520**
Guatemala	22,390	30	3,510	21,180	240	134,650	1,340	3,120	0	**186,460**
Haiti	1,170	0	0	0	0	3,680	0	3,050	0	**7,900**
Honduras	22,870	40	170	60	20	74,730	1,420	4,280	70,320	**173,910**
India	520	20,740	15,420	66,160	219,980	20,290	12,060	996,260	0	**1,351,430**
Indonesia	15,960	50	0	79,960	7,710	292,780	0	972,670	0	**1,369,130**
Ivory Coast	0	0	0	50	210	351,430	0	7,370	0	**359,060**
Israel	510	30	30	580	0	0	470	0	0	**1,620**
Italy	27,420	39,340	930	294,360	490	0	740	1,760	140	**365,180**

Table 24 (continue)

Source/Ha	Fruits	Grain	Legumes	Oil Crops	Nuts	Stimulants	Vegetables	Fibers	Pasture	Total
Jamaica	340	10	0	0	0	2,480	60	0	0	**2,890**
Kenya	0	0	0	0	100	16,000	0	0	0	**16,100**
Madagascar	0	0	0	0	220	6,620	0	800	0	**7,640**
Malaysia	0	10	0	291,810	0	56,850	0	194,080	0	**542,750**
Malawi	0	0	220	0	0	2,740	50	24,780	0	**27,740**
Mauritius	0	0	0	0	0	1,540	0	0	0	**1,540**
Mexico	115,690	39,280	24,120	119,930	0	348,080	113,690	10,180	3,147,050	**3,918,020**
Mozambique	0	0	0	0	340	15,820	0	0	0	**16,160**
New Zealand	4,060	0	740	0	0	0	90	0	3,517,470	**3,522,360**
Nicaragua	440	0	960	10,400	0	33,500	330	180	1,663,350	**1,709,160**
Nigeria	0	0	0	330	170	20,850	0	8,450	0	**29,800**
Pakistan	540	4,940	70	40	0	10	180	600,950	0	**606,730**
Panama	4,580	0	0	0	0	23,240	70	10	0	**27,900**
Paraguay	0	0	0	260	0	1,640	0	0	0	**1,900**
Papua	0	0	0	0	0	37,940	0	0	0	**37,940**
Peru	1,630	340	3,510	60	10	75,910	6,360	0	0	**87,820**
Philippines	23,870	190	0	4,550	80	25,130	50	3,320	0	**57,190**
Rwanda	0	0	0	0	0	2,830	0	0	0	**2,830**
South Africa	8,200	20	0	2,250	360	5,550	550	0	0	**16,930**
Spain	20,480	330	80	87,150	1,490	0	2,030	7,000	0	**118,560**
Sri Lanka	110	10	0	0	310	2,720	650	7,690	0	**11,490**
Tanzania	0	0	0	0	0	2,970	0	550	0	**3,520**
Thailand	16,680	158,790	2,570	900	1,060	29,800	200	187,540	0	**397,540**
Turkey	17,050	5,190	1,830	56,630	7,380	390	750	117,930	0	**207,150**
Uganda	0	0	0	0	0	11,200	0	0	0	**11,200**
Uruguay	0	0	0	0	0	0	0	0	1,940,990	**1,940,990**
Uzbekistan	0	0	0	0	0	0	0	661,210	0	**661,210**
Venezuela	330	640	0	9,450	0	28,210	0	20	0	**38,650**
Vietnam	560	2,650	10	90	23,070	69,190	20	10,790	0	**106,380**
Zimbabwe	0	0	0	0	0	1,740	0	6,760	0	**8,500**

Chapter VIII: Consuming Costa Rica – an interregional approach to ecological change in Costa Rica.

8.1 Introduction

Costa Rica, a relatively small Central American country with a population of 4,326,000 and an area of 51,000 Km2, is often presented as a tropical paradise. It has a unique location between two oceans and serves as a bridge between two sub-continents. The country's dramatic topography includes a volcanic mountainous region, tropical lowlands and coastlines. The climatic variations between regions have made Costa Rica ecologically unique.

Diversity is a key descriptor for all aspects of the Costa Rican natural environment. Although entirely within the tropical latitudinal region, Costa Rica possesses great climatic diversity including three different rainfall regimes (Hartshorn et al. 1983). Holdridge et al. (1971) identify 12 types of natural zones in Costa Rica, ranging from tropical dry and wet forests, to mountain cloud forest and sub-alpine regions.

Although Costa Rica covers only 0.04% of the earth's terrestrial area, it is estimated that between 4% to 6% of the world's species can be found there, making Costa Rica the nation with the highest biodiversity per unit area in the world; more bio-diverse than all of Europe and North America combined (Vaughan et al., 1998; UNEP 2000; INBIO 2007). Overall the number of species estimated to exist in Costa Rica is more than 500,000 (INBIO 2007). About 70% of these are arthropods; fungi and plants represent 12% and 2.5% respectively; the rest are mammals, birds, amphibians, reptiles and fish species. Fewer than 90,000 species, however, have been described. Of those species, 205 are mammals, 600 birds, 12,119 plants, 214 reptiles, 162 amphibians, and 130 fish. The rest are species of arthropods and fungi (INBIO 2007).

Another important element of the country's natural richness and diversity is its soils. Most of the soil orders recognized by soil taxonomists and known to exist throughout the world have been identified in Costa Rica (Bertsch et al. 2000). In general, most Costa Rican soils are fertile and can even be considered very fertile compared to other tropical areas (UNEP 2000). A large percentage of these soils are connected to volcanic activity, and are considered relatively young by world standards.

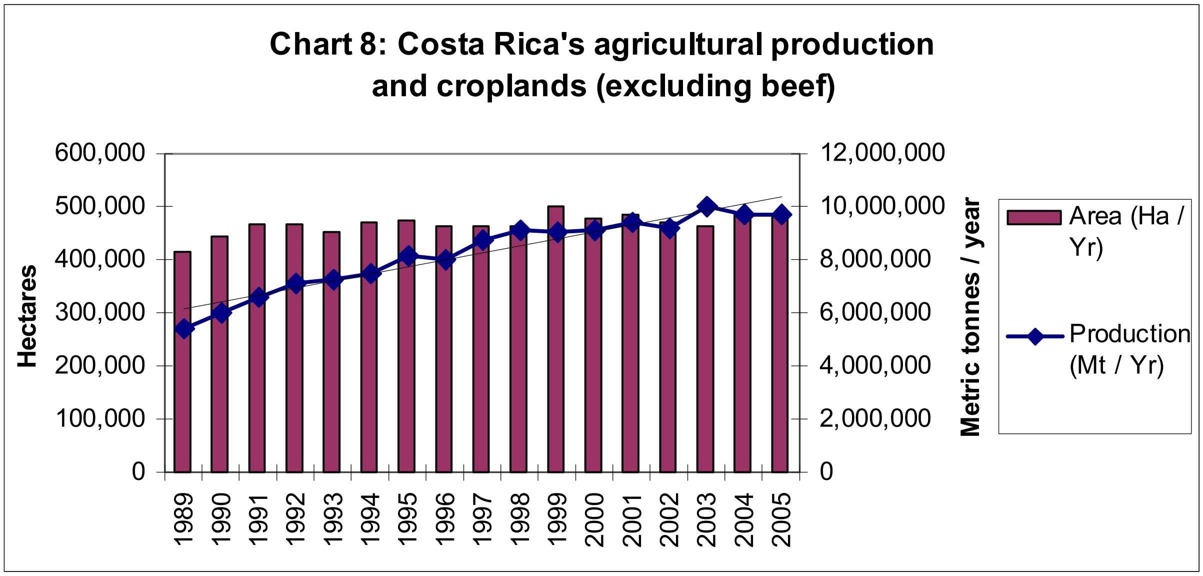
Finally, as in other tropical regions, precipitation is a dominant characteristic of Costa Rica. Costa Rica is perhaps the wettest country in the world, with a nation-wide rainfall average of 3300 mm / year. However, precipitation levels throughout the country are also diverse, a factor that influences flora and fauna, and the creation of the fertile soils discussed above. While the northern and central Pacific regions receive up to 1.8 meters of rain per year and have a long dry season, the rest of the country receives up to 4.8 meters and some mountain regions up to 8 meters (Janzen 1983). Several studies show that in the past Costa Rican land cover was almost entirely forest (e.g., Zon and Sparhawk 1923; Keogh 1984; Vandermeer and Perfecto 2005). That forest cover is the result of the country's physical make-up, and is one of the major means through which its biodiversity is maintained.

Chapter VII identified the external sources of a significant number of renewable resources consumed within the U.S., and the area of land devoted in each source country to producing those resources (including Costa Rica). However, the chapter did not make a direct connection between consumption in the U.S. and specific ecological change in the resource producing regions.

In this chapter I make some of the connections between consumption and ecological change using Costa Rica as an exporting nation case study. I hope to explore the connections between Costa Rica and regions to which it exports, and to link some ecological changes in Costa Rica with consumption in those regions. My focus is on the agricultural sector, and includes most agriculture products produced in Costa Rica (see table 3 in chapter VI). Also, the time frame has been extended beyond that used in the U.S. case (chapter VII) to include production between 1989 – 2004; this timeframe allows me to identify patterns of ecological change and to make stronger connections between production for export and ecological change. As discussed in the research method chapter (chapter VI), I first quantify key inputs (in this case land, water, and chemicals) required to produce agricultural products in Costa Rica. Then I assess how much of these inputs can be associated with supporting consumers in other regions of the world. Next, I describe some of the major ecological change processes in Costa Rica over the last few decades. I then highlight the ecological changes related to growing specific export products. While the following paragraphs summarize the research results, appendix 2 presents the detailed data.

8.2 Agricultural production

Historically Costa Rica has had an agriculture-based economy. Despite recent changes, agriculture is still a significant part of the economy and a major source of foreign exchange (Hall et al. 2000b:124; MAG 2004). Above all, it is a way of living and a main source of employment for a large part of the Costa Rican population and many foreign workers from neighboring countries (Vandermeer and Perfecto 2005). My study includes 29 agricultural products which represent the majority of agricultural products grown in Costa Rica (MAG, 2005; FAOSTAT, 2007). Chart 8 shows an overall increase in production of these crops, from 5.5 million Metric tonnes (Mt) in 1989 to about 9.8 million Mt in 2005. It also shows an increase of the area of land required for that production (see appendix 2 table 1 and 2 for the complete data). The following chart 9 presents beef production.



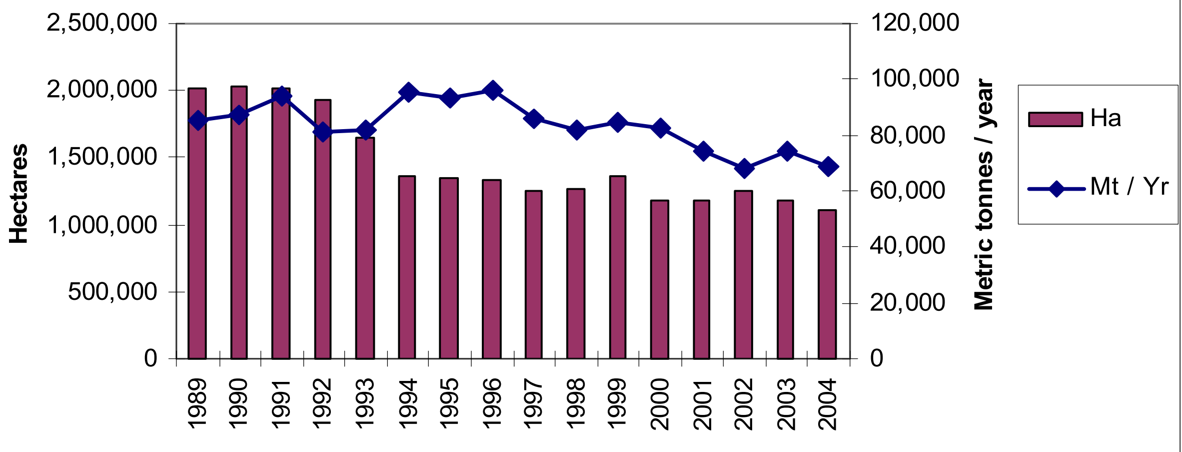


Chart 9: Costa Rica's Beef production and cattle pasture land

Production of these agricultural products requires several physical inputs. Table 25 presents the changes in land, water and chemical inputs involved in the production of these products; it does not include inputs required for beef production which will be discussed separately (for detailed data see appendix 2 tables 2, 3, 4 and 5).

Table 25: Physical inputs to agricultural crops production

		1989	**1992**	**1995**	**1998**	**2001**	**2004**	**2005**
Land[20]	Ha	411,600	459,900	465,100	458,200	498,700	472,400	483,400
Water[21]	1000 M3	3,837,300	4,460,800	4,494,900	4,613,900	4,931,700	4,996,400	4,945,000
Fertilizers[22]	Mt	107,000	123,000	122,000	199,000	172,000	152,000	159,900
Pesticides[23]	Mt	12,200	13,800	14,600	19,100	20,000	20,000	19,900

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[20] MAG 2005; FAOSTAT 2007

[21] Hoekstra and Chapagain (2004; 2006). The Water footprint of nations data base.

[22] IFDC 1997; IFA 2006; Rubin and Hyman 2000; MAG 2005; FAOSTAT 2007

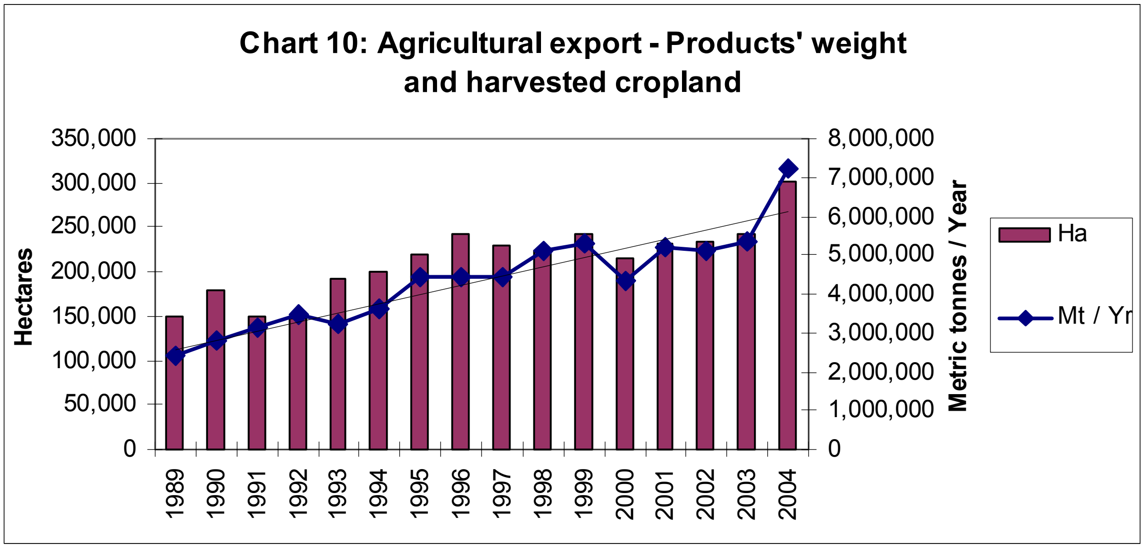
[23] De La Cruz and Castillo 2003; FAOSTAT 2005

8.3 Costa Rica's interregional ecology

While several factors likely contribute to increasing agricultural production in Costa Rica, including population growth and increases in per capita consumption, it seems that within the study period the major factor is trade. Costa Rica is keen to extend its trade relations (as a source of foreign currency), and there is increasing overseas demand for Costa Rica's products. While export of products such as bananas, coffee, sugar, and beef has always been a major part of the Costa Rican economy, a few important changes can be identified within the period discussed here:

1. An increase of total crops exported and of the required land inputs (Chart 10 and appendix 2 table 6 and 7).

- A decline in exports of beef products and in the size of pastureland (appendix 2 table 8).
- A change in the proportion between production for local consumption and that for export (Chart 11). In 1989 about 44% of the production weight was devoted to export, in 1999 about 58% and in 2004 about 74%. An increasing portion of Costa Rican production has become devoted to consumers in other regions of the world, thus increasing foreign consumers' footprints on Costa Rica (Charts 10 and 11 and the following table 26; see also appendix 2 tables 6 and 7).



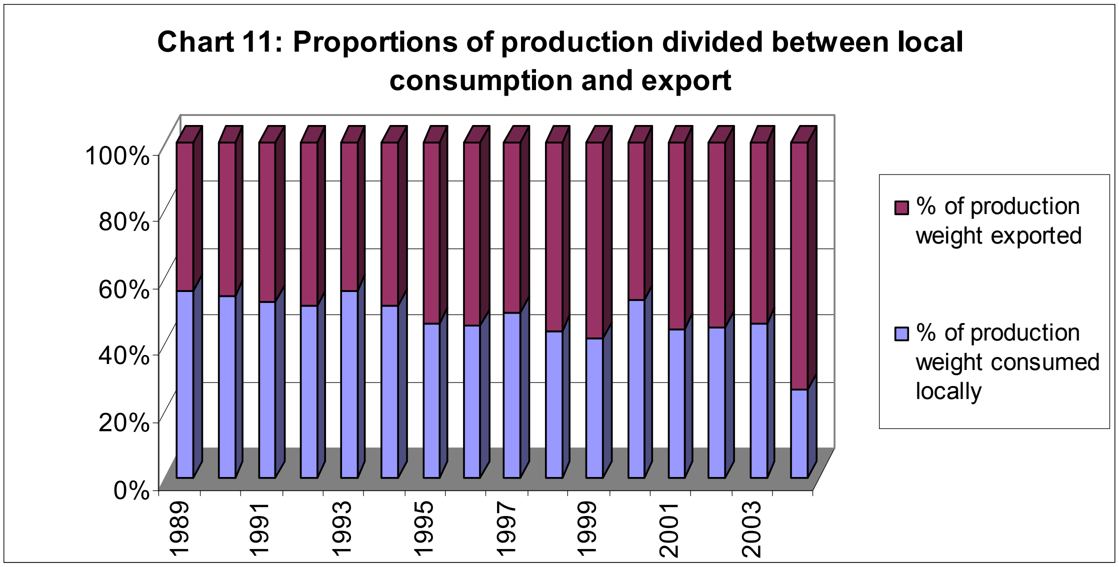


Chart 11: Proportions of production divided between local consumption and export

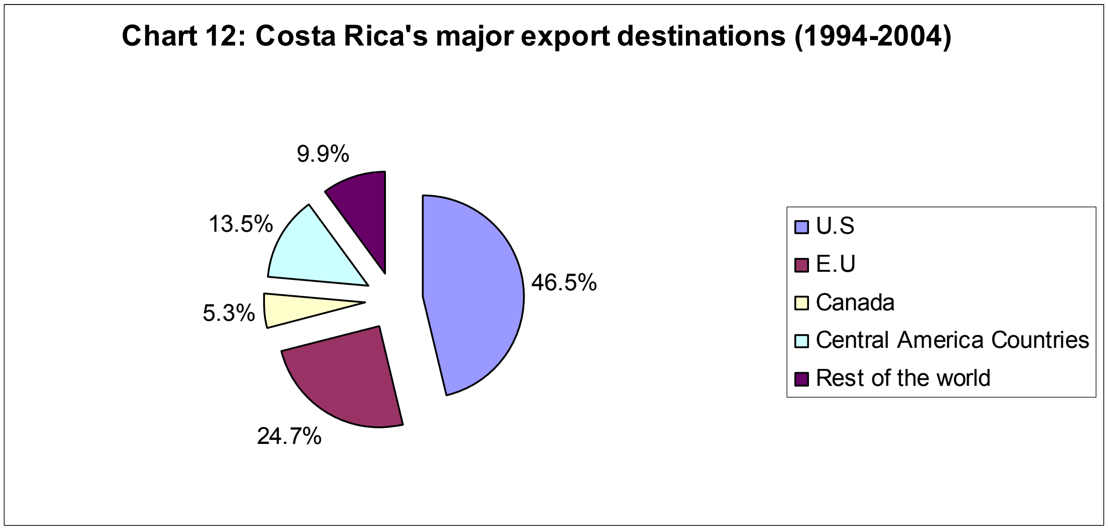


Chart 12: Costa Rica's major export destinations (1994-2004)

The U.S. and the E.U are the major destinations for Costa Rica's agricultural exports (over 70% of the study products by weight). As shown in chart 12, on average within the study period 46.5% and 24.7% of the total mass of export crops were exported to the U.S. and the E.U respectively. Weight is a useful measure of exports, however, the land area required to grow them differs among products. Thus the percentage of crop land in Costa Rica devoted to growing export crops (not including beef) for the E.U for example is higher than the percentage weight, of the export products: 32.9 % versus 24.7%. Canada is also a major trade partner and imports an average of 5.3 % of Costa Rica's exports by weight, at 2.8% of the crop land devoted to export (for detailed data see appendixes 2 tables 9 and 10). The following chart 13 presents the amount of land devoted to each importer.

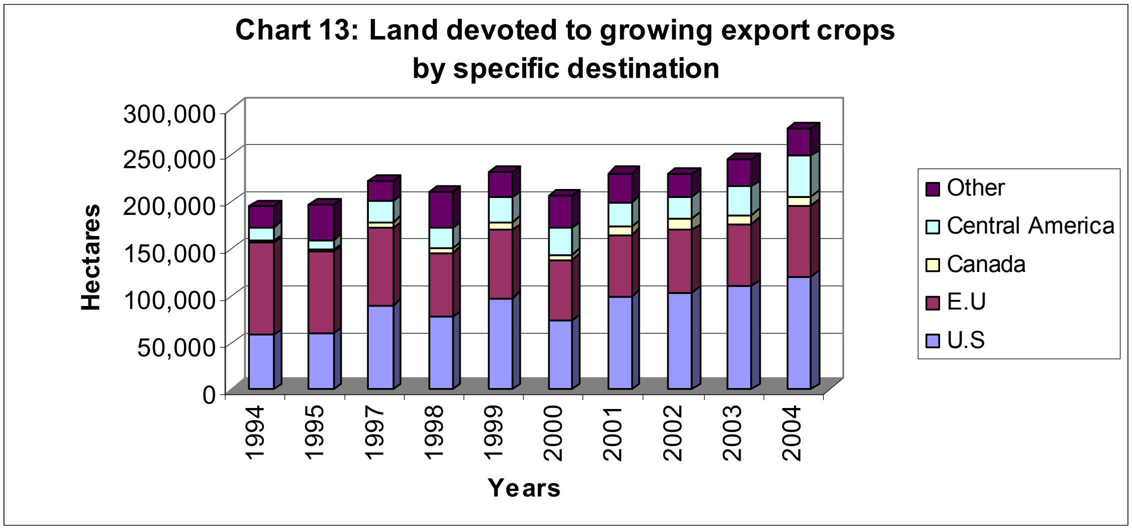


Chart 13: Land devoted to growing export crops by specific destination

While Costa Rica's agricultural sector grows and exports diverse products, eight major crops and beef capture most of the export (in terms of total weight and required inputs). Table 26 presents Costa Rica's major export products and the required inputs measured in my research (for detailed data on these and other products please see appendixes 2 tables 6 and 7).

Table 26: Costa Rica's export and required physical Inputs (1989-2004)[24]

	Production and export weight			**Average Inputs devoted for export**			
	Average export	**% of production**	**Average annual change**	**Land**	**Water**	**Fertilizers**	**Pesticides**
	Tonnes	%	+/- %	Hectares	1000 M3	Tonnes	Tonnes
Bananas	1,938,560	90.3	+ 2.6	40,600	594,800	40,600	2,100
Cassava	117,490	41.5	+ 13.4	7,840	65,560	5,490	N/A
Coffee	129,440	86.8	- 0.9	94,840	1,236,700	54,000	620
Melons	130,600	68.4	+ 19.3	4,780	17,110	1,510	100
Oil palm	303,600	58.0	+ 34.8	17,510	229,820	3,500	N/A
Oranges	174,040	71.1	+ 40.4	14,300	116,960	4,300	N/A
Pineapple	371,190	56.1	+ 21.4	6,010	27,470	2,120	120
Sugar	1,291,380	37.5	+ 14.6	16,180	182,940	3,000	52
Other crops	46,300	7.7		19,420	138,040	6,900	N/A
Total Crops	**4,502,600**	**54.6**	**+ 8.2**	**221,480**	**2,609,400**	**121,420**	**N/A**
% of overall production				48%	57%	82%	+/- 40%
Beef (head)	**91,580**	**25.0**	**+ 3.9**	**369,240**	**N/A**	**N/A**	**N/A**

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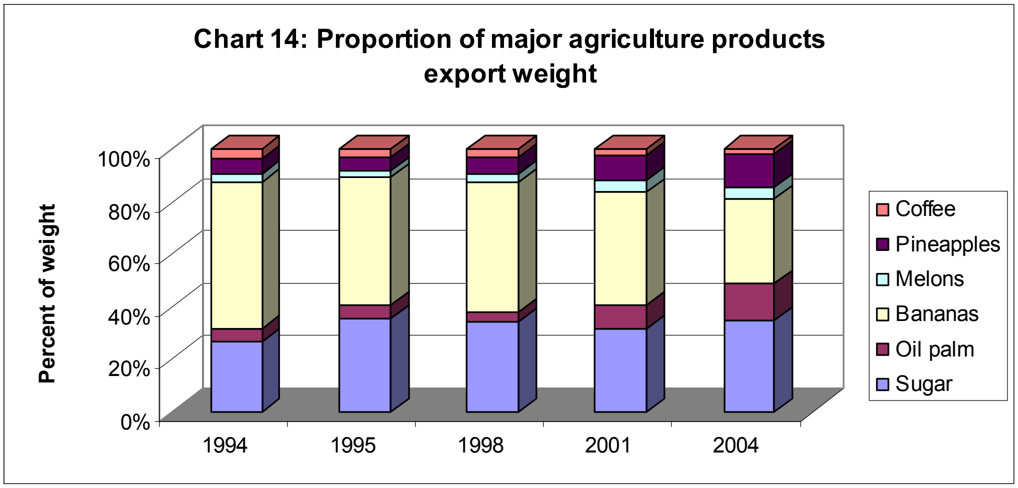
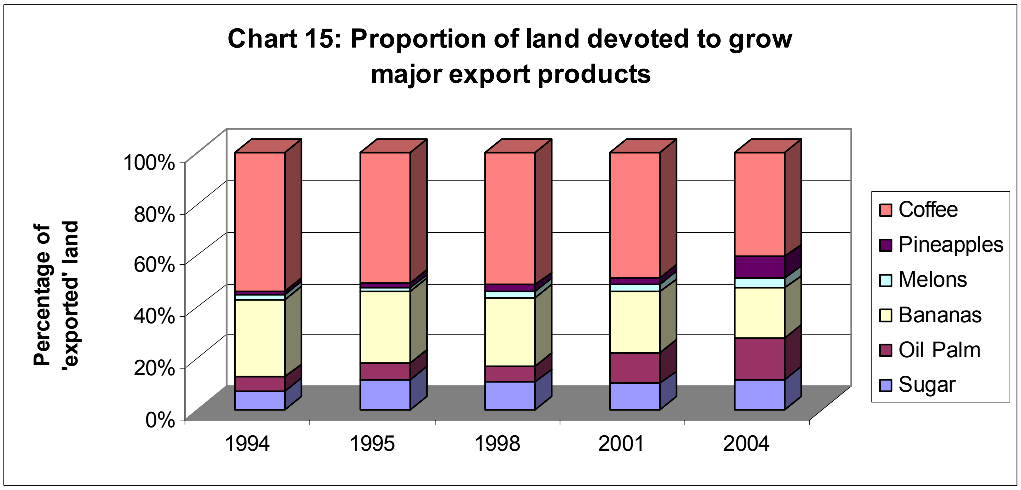
[24] I used data from the following sources: UN-COMTRADE 2006; FAOSTAT 2007; MAG 2005; Hoekstra and Chapagain 2004. IFDC 1997; IFA 2006; Rubin and Hyman 2000; De La Cruz and Castillo 2003; FAOSTAT 2005

Chart 14 presents each product as a percentage of combined total export weight for these eight products, and chart 15 presents the proportion of land devoted to growing each product. For example while on average, sugar is 27% of the export weight (chart 14), it requires less than 8% of the land (chart 15). On the other hand coffee requires almost 40% of the land to produce less than 3% of the export weight (appendix 2 table 7 present the detailed land devoted for each crop within the research period). These charts illustrate again the importance of following the physical inputs involved, to trace the connections between certain production and pressure on the ecosystem looking at the weight of imported commodity need to be supplemented with the physical inputs involved in that commodity production.





After identifying the different products grown / produced in Costa Rica, quantifying the inputs needed for each product separately and together for the whole sector, and identifying the proportion of inputs associated with production for export, I would like to understand what role that production plays in ecological change in that country.

8.4 Ecological change

Costa Rica has been facing human-induced ecological change since the colonial period; increasing population and the introduction of new activities (e.g., coffee, pasture) have contributed to that process. However, it is mostly the 20th century and more precisely, the second half of that century that has brought about significant change (Hall et al. 2000a). In this section I first explore historical ecological change in Costa Rica as described in the literature. I then focus on Costa Rica's agricultural sector and investigate connections between activities in that sector and ecological change. Finally I take a 'specific products' approach to linking physical inputs to ecological change. The specific products I have selected are bananas, coffee and beef production.

8.4.1 Land Use and land cover change

One of the most significant factors that directly and indirectly contribute to ecological change in Costa Rica is land use and land cover (LULC) change. Since the late 1970s several studies have made an effort to document LULC changes at both the national (e.g., Seder and Joyce 1988; Sanchez – Azofeifa 1996; 2000; 2001; Kleinn et al. 2002; 2005) and regional (e.g., Veldkamp et al. 1992; Veldkamp and Fresco 1996; Jansen et al. 2005) scales. The development of remote sensing and Geographical Information Systems (GIS) has contributed to both the scope and accuracy of these studies. Table 27 presents the major LULC changes in Costa Rica from 1979 to 2004.

Table 27: Costa Rica major land use and land cover 1979 – 2004 (Ha)[25]

	1979 (Ha)	1992 (Ha)	2000 (Ha)	2004 (Ha)
Natural Forest	2,085,900	1,286,500	1,163,200	1,269,900
Pasture[26]	1,940,000	2,340,000	1,349,600	1,349,600
Cropland[27]	347,300	459,900	485,100	472,400
Urban	14,700	22,600	35,000	N/A
Other[28]	712,100	991,000	2,067,100	2,008,100
Total	**5,100,000**	**5,100,000**	**5,100,000**	**5,100,000**

Change in Forest land – Probably the most significant land cover change in Costa Rica within the last several decades has been forest change. The change in the amount and structure of the Costa Rican forests has implications for all other ecological changes discussed in this chapter. Zon and Sparhawk (1923; as cited in Cornell 2000) estimate that at the end of the 19th century 95% of Costa Rica was forested. Since then a process of deforestation and degradation of the forest has occurred.

Three approaches have been used to detect forest change in Costa Rica:

- Deforestation rates - the size of the forest and the annual rates of change
- Density of the forest canopy - usually used to make a distinction between natural, secondary or cultivated forests, or between young and mature forests.
- Number and size of forest patches (islands)

It is the combination of all three that provides us with a comprehensive picture of Costa Rica's land cover.

(I) Deforestation – while there are several estimations of deforestation rates, there is no debate about the fact that Costa Rica has lost a significant portion of its forest within the last several decades. According to Kleinn et al., (2002), most forest studies addressing the time period between 1940 and 1990 show a constant decline of forest cover (from around 70% in the 1940s to about 30% in 1990). For example, Sader and Joyce's (1988) study reveals that between 1940 and

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[25] Costa Rica Ministry of Agriculture 1996; Costa Rica Ministry of the Environment 2000; World Bank 2000; EDN 2004; Bonilla and Rosero 2004; Kleinn et al. 2002. FAOSTAT 2007.

[26] 2004 data based on 2000 data.

[27] Include both annual and permanent crops.

[28] Other land use and cover include: secondary forests; harvested forests, forest plantations, and mangroves. fallow areas; Swamps; bog land; rocky lands; burnt areas. For 2000 and 2004 it includes urban areas as well.

1983 Costa Rica lost about 50% of its closed cover natural forests. Camino et al. (2000) show that between 1979 and 1992 the natural forest shrank by almost 800,000Ha. From 1950 to the beginning of the 1990s the annual average deforestation rate was 3.9% (Kleinn et al., 2002).

Since the 1990s, Costa Rica is often presented as a success story in terms of conservation and high awareness of sustainability issues. Indeed, currently about 25% of the country is under some kind of conservation (Evans 1999; Brandon 2004). Also, large areas are being reforested. The total area of secondary forests and forest plantation increased by 10% during the 1990s (WRI 2006). In spite of what seems to be a positive change, a deeper examination of LULC processes reveals a continuation of natural forest decline (e.g., Vandermeer and Perfecto 2005; Kleinn et al 2005; Wassenaar et al. 2007). According to WRI (2006) and FAO (2006) between 1990 and 2000, a decrease of about 10% in natural forests was recorded. A World Bank study (1996) identified three major types of forest intervention during the 1990s: (a) continuous clear cutting in order to change forest cover to agricultural lands. (b) A selective cutting of large, valuable trees in primary or secondary forests, and (c) exploitation of specific trees in forest patches within pasture areas.

(II) Canopy closure - The development of aerial photography and more recently satellite remote sensing contribute to our knowledge of the state of the world's forests (FAO 2006). Most forest studies in Costa Rica make use of such tools; however study results vary with technology choice and inconsistency of definitions (Kleinn et al 2002). Significant contradictions in findings can ensue. For example, using measurement of tree canopy closure to assess the state of Costa Rica's primary natural forests produces data contrary to the forest figures presented in Table 27 and discussed above; measurement of tree canopy closure reveals that the size of Costa Rica's primary natural forests is in continuous decline (Sader and Joyce 1988; Sanchez-Azofeifa 1996, 2001; Costa Rica forest services 2001; Kleinn et al. 2005). While most of the natural forest declined before 1989 (from 3,420,600 Ha in 1940 to 1,615,400 in 1977) by 2000 the area of natural forest continued to decline and reached 1,163,150 Ha

(III) Forest patches – In addition to the total remaining forest area, another important aspect of ecological change that has received some attention recently is the size of forest patches and their spread around the country. Sanchez (1996), the Costa Rica Ministry of the Environment (1998) and Sanchez et al. (2001) have estimated the number and size of these forest islands. These studies emphasize the extent of forest fragmentation. These studies show an increase of forest patches from 3,690 in 1986 to 7,889 in 1991. Moreover, most of these patches are small between the size of 3 to 50 Ha (3341 patches in 1986 and 7134 in 1991). Considering the fact of increasing forest fragmentation on top of the overall deforestation make that process even more severe in terms of its ecological consequences (e.g., for biodiversity)

8.4.2 Soil degradation

The main source of physical soil degradation in Costa Rica is hydraulic or flowing water. More than 40% of Costa Rican lands suffer from deteriorating soil conditions (Bertsch et al. 2000; CIEDES 2004). Most of the degradation is either slight or moderate, however in 1981 and 2001 a significant amount of the degraded soils were under severe or very severe degradation (38% and 44% respectively). An FAO (2005) study shows far higher rates of degradation claiming that in 2004 2,915,000 Ha (57%) of Costa Rica's lands were under severe or very severe degradation.

In addition to investigating the extent of soil degradation, several studies have estimated the amount of soil which has been eroded. The change in the structure of the land is a natural process and not all soil erosion is necessarily negative. However in certain circumstances it can have negative ecological consequence*s*. There are significant differences in results among studies due to methodological differences. For example, Repetto and Cruz (1991; as cited in Rubin and Hyman, 2000:452) estimated erosion of 121.8 million T/yr in 1970 and 188.6 million T/yr in 1984. The Costa Rica Ministry of Agriculture (as cited in Bertsch et al. 2000:290) estimated the total erosion for 1984 at 224 million T/yr. On the other hand, Rubin and Hyman (2000:461, following Jeffery et al. 1989) presented moderate estimates for 1973, ranging from a minimum of 17.4 million T/yr to maximum of 90.5 million T/yr depending on land use scenarios.

8.4.3 Biodiversity loss

Costa Rica has one of the highest biodiversity rates in the world (INBIO 2007; Vandermeer and Perfecto 2005; Frankie et al. 2004; Evans 1999). At the same time, both natural processes and human activities are contributing to a decline in its diversity. Species disappearance can have a direct and negative effect on the wellbeing of other animals and plants, and may indirectly impact other ecological services such as soil fertility and pest control (MEA 2005). It is difficult to determine the rate of species extinction, as the number of species that have gone extinct or are threatened in Costa Rica are poorly documented. However, there is a good chance that many different species have already disappeared.

In recent years several studies have attempted to estimate the number of species under threat of extinction in Costa Rica (e.g., MINEA 2000; UNEP 2000; Groombridge and Jenkins 2002; Costa Rica Development Observary 2006). From these sources, the number of species under threat of extinction is in the range of 13 – 28 mammals, 18 - 102 birds, 60 - 83 amphibians, 8 - 36 reptiles, and 13 fish. Out of the 12,119 species of plants identified in Costa Rica, 527 are under threat of extinction. Most of Costa Rica's species are insects (estimated at more than 300,000 species); more than 75% of these are forest species. Therefore the disappearance of forest and specific plant species within forests reduces the number of insects as well.

8.5 Agriculture and ecological change in Costa Rica

In Costa Rica, agricultural activity – both livestock and crop production - is a major driver of ecological change. In exploring the connections between agricultural activities and ecological change, a distinction needs to be made between direct, indirect and potential impacts. The major direct impact documented here is habitat loss. It can lead to several indirect impacts such as soil degradation and biodiversity loss. Potential impacts can be chemical and biological soil degradation and water contamination as a result of agrochemical use. While the discussion in this section will be at the general level and will focus on the connection between the agricultural sector and ecological change, the following section will focus with higher resolution on specific agricultural products and will make an effort to account for their part of the bigger picture of ecological change and production for trade in Costa Rica.

8.5.1 Agriculture and habitat change

Loss of forest cover is the main habitat change in Costa Rica (e.g., Sanchez-Azofeifa 2000; Hall et al. 2000a). Agricultural expansion has contributed to LULC change in the last few decades. Table 28 presents land use by each of the main agricultural groups and total change in agricultural lands since 1979.

Table 28: Annual and permanent agricultural lands[29]

	1979 (Ha)	1989 (Ha)	1992 (Ha)	1997 (Ha)	2000 (Ha)	2004 (Ha)
Active Pasture	1,940,000	2,320,000	2,340,000	1,565,100	1,349,600	1,349,600
Annual crops	101,400	219,900	227,900	218,700	221,300	200,200
Permanent crops	246,300	191,700	232,000	239,400	263,800	272,200
Total	**2,287,700**	**2,731,600**	**2,799,900**	**2,023,200**	**1,834,700**	**1,822,000**

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[29] Costa Rica Ministry of Agriculture (2005), and FAOSTAT (2007). 2004 pastureland based on 2000 data.

It is obvious from the above table that livestock is responsible for most land cover changes within the last several decades. (A more specific discussion of the connections between beef production and ecological change in Costa Rica is included in the next section of this chapter.) However, other agricultural activities have played an important role in the process of land cover changes as well: (I) many pasture lands were previously forests that were turned into crop lands before being converted into pasture (Ibrahim et al. 2000:426). (II) From 1979 to 2004 there was a significant 48% increase in the amount of croplands. In the same time period more than 56,000 ha of forest were converted to croplands (Camino et al. 2000). Unlike the livestock sector that has been minimized throughout the last 15 years or so, land use by both annual and permanent crops has significantly increased and continues to do so. For example, according to Camino et al. (2000), within the same period, about 140,000 ha of pasture lands became crop land (mostly permanent crops). As will be discussed later on in this chapter, the recent expansion of croplands has occurred on both previous pasture lands, and primary and secondary forest lands. A recent study (Wassenaar et al. 2007) estimated that between 2000 and 2010 Costa Rica's forests will decline by an additional 100,000 ha of which 59,000 ha are for pasture and 41,000 ha for crops.

8.5.2 Soil Degradation

As in the case of habitat change, there are several causes of soil degradation. Some changes are natural processes and are a consequence of extreme weather phenomena, while others might be a combination of human intervention and natural processes. As it appears from several studies, agriculture plays a central role in soil degradation in Costa Rica (e.g., Rubin and Hyman 2000; Bertsch et al. 2000; Ibrahim et al. 2000; Vandermeer and Perfecto 2005).

While the erosion of the soil does not solely occur on agriculture lands, the relatively bare agriculture soils are much more fragile to extreme hydraulic pressure (Rubin and Hyman 2000:458). For example, it has been estimated that in forest areas the average soil loss is 2.6 tonne/ha/yr; in agriculture annual croplands it is 20.7 tonne/ha/yr; in permanent crops it is 10.8 Tonne/ha/yr; and in pasture 4.2 Tonne/ha/yr (Rubin and Hyman 2000:460).

Following Rubin and Hyman (2000:460), as for 1992, 62% of eroded soils in Costa Rica are agricultural soils (50% pasture, 29% permanent crops and 21% annual crops). Other eroded soils are within forest areas. But while the natural forest environment is mostly resilient to such processes, the erosion of agricultural soils can affect the physical structure of the soil, and its biological and chemical textures, which can lead to reduction in the productivity of the land (Ibrahim et al. 2000:437). It can also affect other nearby ecosystems such as rivers and streams (Sanchez 2001), and marine ecosystems that might be miles away (Cortes and Jimenez 2003:223). Another major form of soil degradation is the loss of vital nutrients from the soil (UNEP 2000; Lal et al. 2004). The nutrients that are vital to both the soil and plants might be lost as a result of inappropriate or over-intensive use of the land. Lost nutrients due to soil degradation are compensated for by use of fertilizers. Fertilizers have two purposes, to maintain the quality of the soil, and to increase agricultural yields. The use of commercial fertilizers by the Costa Rican agricultural sector has significantly increased throughout the last few decades from 73,500 tonnes of commercial fertilizers at the beginning of the 1980s to as high as 199,000 tonnes at the late 1990s and around 160,000 tonnes in 2005 (FAOSTAT 2007). This is a result of a total increase in agricultural production, an attempt to maintain and increase yields, and to maintain the quality of the soil. According to the WRI (2007) the use of fertilizers per hectare of agriculture land is one of the highest in the world – 342 kg/ha in Costa Rica compare to the world average of 94 kg/ha. Other than the direct pressure chemical fertilizers put on the soil's biological content where they have been applied, a main problem is the loss of chemicals through leaching (Robinson 1996:135; Lopez 1998:72), which can have an impact on a much wider range of ecosystems outside the field / plantation area and can indirectly affect untouched natural areas.

8.5.3 Pesticide contamination of land and water

The agricultural sector is the primary consumer of pesticides in Costa Rica. Indeed, increasing monoculture-type agriculture in Costa Rica is a major reason for the intense use of pesticides in that country (De la Cruz and Castillo 2003:369). This method of agricultural activity depends heavily on pesticides, which directly and indirectly contribute to ecological deterioration such as: soil contamination, aquatic ecosystem degradation, biodiversity loss, development of pest resistance, and the emergence and proliferation of secondary pests (Castillo et al. 1997:50; Henriques et al. 1997; De la Cruz and Castillo 2003:369).

The total amount of pesticides imported into Costa Rica has increased from about 5.6 million kg in 1970 to 14 million kg in 1996 and 18 million kg in 1997 (De la Cruz and Castillo 2003:343). De la Cruz and Castillo (2003:345) estimated that between 1985 and 1997 a total of 134,545 tonnes of pesticides were used in Costa Rica, again almost entirely by the agricultural sector. The average use of pesticide for cultivated land (Ha) has also increased, from 16 kg / ha / yr within the 1980s, to more than 41 kg / ha / yr in the late 1990s (Castillo et al. 1997:42; De la Cruz and Castillo 2003:349). While there are more than 700 pesticide formulations containing about 200 different active ingredients registered in Costa Rica, they can be divided into three major groups:

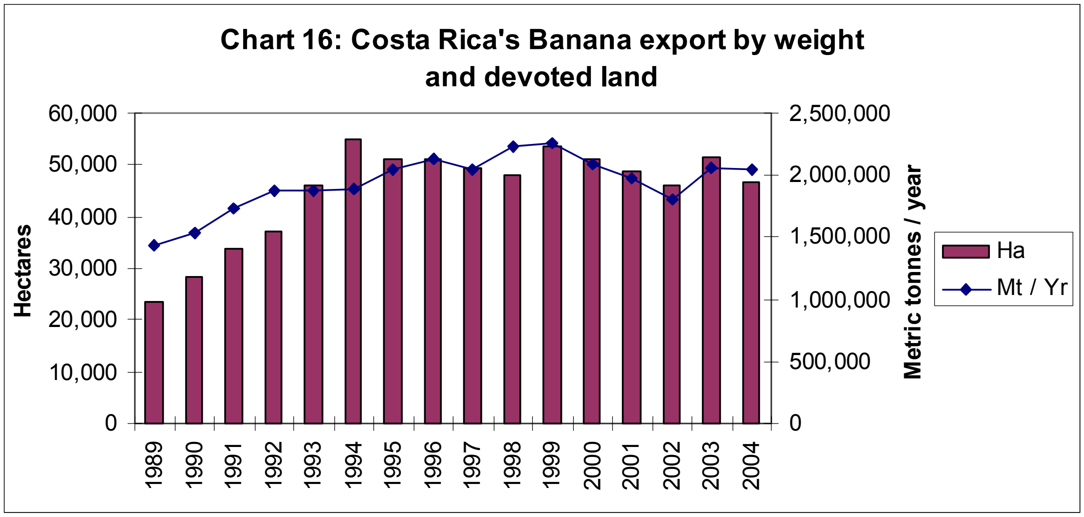
fungicides (47% of pesticides use), herbicides (27%) and nematicides and insecticides (16%). Each group of chemicals is involved in different parts of agriculture production, and carries its own threats (Henriques et al. 1997). Some more specific ecological results of these chemicals are discussed in the next section of this chapter.

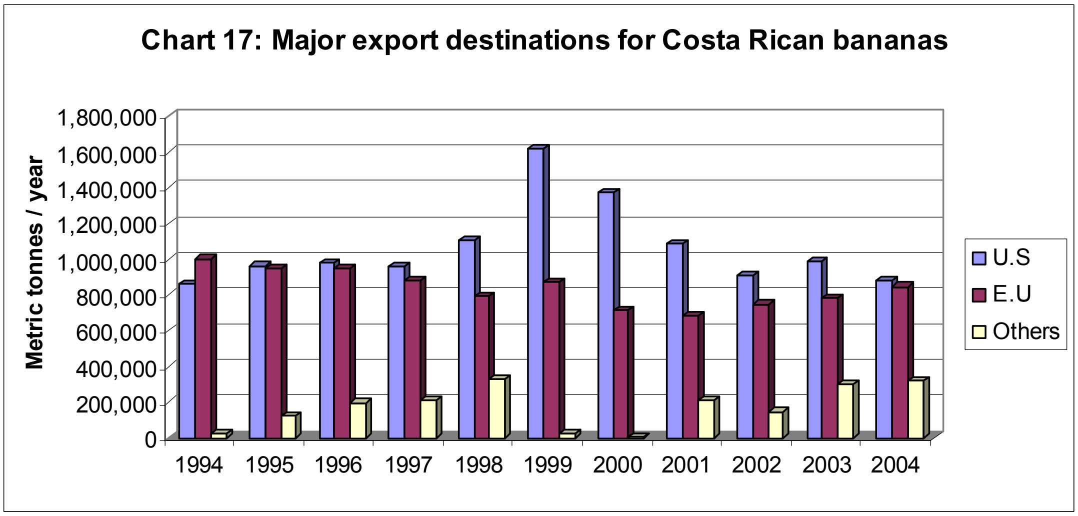
8.6 Specific products and their connections to ecological change

The purpose of this section is twofold: to trace the interregional connections of specific products, and to make the linkages between growing these agricultural product(s) and the ecological processes discussed in this chapter. As stated previously the Costa Rican agricultural sector is diverse and includes many products for both local and international consumption, but only a few products constitute the vast majority of the production. To fully understand the interregional connections other countries have with Costa Rica we need to capture the life cycle of each product. This study uses examples of three major export products – bananas, coffee, and beef, and connects them to the ecological processes discussed above.

8.6.1 Bananas

Banana production in Costa Rica goes back to the late 19th century and has since been connected to international markets, government incentives, and the interests of multinational companies. Banana production has become one of Costa Rica's most important economic activities, both as a main source of foreign exchange and a major source of employment. In recent years Costa Rica has become one of the major bananas suppliers of the world (Clay 2004:238). Several studies have discussed the political economy of the banana sector in Costa Rica (e.g., Lara et al. 1995; Vandermeer and Perfecto 2005). These studies are important for understanding the development and drivers influencing that sector. The main focus of this section is on the connections between banana production and ecological change in Costa Rica. The following charts 16 and 17 present the change in volume of banana exports within the studied period, and their major destinations:





In terms of ecological change, the production (i.e., growing and packaging) of bananas can be connected to: land cover change, soil degradation and water contamination. Astorga (1998) divides the history of Costa Rica's banana industry and related ecological change into three phases: (1) 1870 to 1960: intensive but shifting cultivation, characterised by very low productivity, high levels of deforestation of primary forests, low consumption of agrochemicals. (2) 1960 – 1980: characterised by a transformation of the plantation into perennial intensive cultivation, with moderate to high yields. A change of banana variety brought with it a plant of greater vigour but low resistance to pests and diseases. This brought about an increase in the use of agrochemicals. (3) Since 1980, the industry is characterised by even higher productivity but still low resistance to pests and diseases, and therefore a high level of dependence on agrochemicals. This period is also characterized by expansion of the banana lands, in certain cases on primary and secondary forest lands.

8.6.1.1 Bananas and habitat change

The area of banana plantations in Costa Rica has increased significantly during the research period, from 28,720 Ha in 1989 to 56,690 in 1997 and to 52,760 in 2004 (MAG 2005; FAOSTAT 2007). Unfortunately, to my best knowledge, there is no single study that followed banana plantation expansion over primary forests throughout the years. Although it is obvious from the above data that banana territories have expanded significantly, the area of forest cleared for banana plantations is probably even larger. Banana plantations use a certain amount of land until productivity declined then moved on to the next location usually by deforesting new land (Astroga 1998; Vandermeer and Perfecto 2005).

Most banana plantations have always been located within the Atlantic region of Costa Rica in the province of Limon, which is characterized by tropical wet and moist forests (Hernandez et al. 2000). Evidence from several studies supports connections between banana cultivation and habitat change. Zamora et al., (2001:147) looked at the Costa Rican agricultural sector at the beginning of the 20th century; they documented an increase in the size of banana plantations of more than 33,000 Ha between 1905 and 1927, all of it on previously forested land. It has been estimated that between 1960 and 1972 a forested area of 15,150 ha was cleared in central Limon province. Of that cleared area, in 1972 about 5,880 ha became new banana plantations (Veldkamp et al. 1992:78). During the expansion of the banana industry from 1979 to 1992, about 13,900 Ha of primary and secondary forest in that province was converted into permanent crops (Camino et al. 2000). At the beginning of the 1990s more forest areas became banana plantations; according to the corporation of banana producers 4,677 Ha of forest were cut at that time. Others argue, however that the amounts were much higher (e.g., Clay 2004:247; Lustig 2004; McCracken 1998; Foro emaus 1998:40). Van Laake and Sanchez – Azofeifa (2004) followed processes of LULC change in that province between 1986 and 1997; they showed a deforestation rate of 8.4% for this period. While it is obvious that not all deforestation processes can be connected to the expansion of banana plantations, the study focused on three areas where most changes occurred and found that in the canton of Siquirres, where most bananas are grown today, the deforestation level was 44.8 %.

8.6.1.2 Bananas and Soil degradation

Due to their high nutritional needs, banana plantations are established on the most fertile lands (Clay 2004). One characteristic of tropical soils is their dependence on the bio-mass of the forest. Once the protective forest cover is eliminated, the productivity and soil fertility per unit of area declines sharply (Astroga 1998:3). The lack of ground cover and the deficiencies of natural and artificial drainage within most banana plantations lead to soil erosion. According to Robin and Hyman (2000), about 10.8 tonne/ha/yr of soil are eroded as a consequence of permanent crops cultivation in Costa Rica. The banana plantations are located within the wet tropical region of the country where precipitation levels are high, and can lead to flooding. As a consequence, the soil has been effectively degraded into silt, with the knock-on effect of increasing sedimentation in adjacent bodies of water and in the Caribbean Sea, affecting the coral reef environment (Astroga 1998:4; Cortes and Jimenez 2003:225).

Another major component of soil degradation is chemical change resulting from the high nutrient demand of bananas. These demands can be supplied either by growing the crop in very fertile soils or by supplementing moderate soil fertility with applied fertilizers (Robinson 1996). Banana plantations require flat terrain and deep, well-structured, and well-drained soils with a high balance of nutrients (especially potassium). The best soils are those found in the alluvial plains and on volcanic ash deposits (Hernandez et al. 2000). These soils, however, depend on the bio-mass of the forest for their fertility. Once the protective forest cover is eliminated and replaced with banana plantations, the productivity and soil fertility per unit of area declines sharply (Astroga, 1998:3).

As mentioned, most bananas plantations have been located within the Atlantic region of Costa Rica in the province of Limon. Within that region two major groups of soil can be identified: the first is mainly volcanic in origin, characterized by medium to low fertility, and slight acidity problems. These soils require the application of several inputs such as: nitrogen, phosphorus, magnesium, sulphur and calcium. The other group comes from accumulated particles sedimented from marine deposits, making them very fertile, without acidity problems. While they also require a significant amount of fertilizers they do not need calcium or magnesium and require only very low amounts of phosphorus (Lopez 1998). However, even the most fertile soils sooner or later become depleted and require additional fertilizers (Robinson 1996). In Costa Rica almost all of these fertilizers are synthetic, and only a small portion comes from organic sources (Lopez 1998). According to Lopez (1998:67) the average amounts of fertilizers required (kg/ha/yr) by banana growers are as follows: nitrogen (N) 350; potassium (P2O5) 50; phosphorus (K2O); magnesium (MgO) 50; sulphur (S) 60. However, while these are the recommended amounts the actual amounts used appear to be much higher (Astroga 1998; Clay 2004). Following data from (FAOSTAT 2007; IFA-FAO 2002) on average during the research period banana used 36% of the overall Costa Rican fertilizers use.

The use of these chemical fertilizers supplements natural nutrients in the soil (Robinson 1996). A significant part of the nutrient input does not remain in the soil or in the plant, but is lost either in the fruit itself (about 50% of the input nutrients) or through leaching into the ground (Robinson 1996:135; Lopez 1998:72). The combination of intensive, high yield cultivation and high nutrient demands puts the soil nutrient balance at risk. A change in the balance between inputs and outputs degrades the soil, requiring more and more external fertilizers and causing a reduction in yields.

8.6.1.3 Bananas and ecosystems contamination

The use of chemicals poses another threat to ecosystem structure and function, both within the banana plantations and outside the plantations in locations further away. The banana industry is a major user of chemicals (both fertilizers and pesticides), and these chemicals are one of the largest sources of pollution from banana plantations (Hernandez 1996; De la Cruz and Castillo 2003; Lustig 2004). Of all potential impacts of growing bananas in Costa Rica, pesticides and their role in degrading the natural environment have received a relatively significant amount of attention by researchers, policy makers, and some consumer organizations. Still, we are very far from knowing the exact inputs, and understanding the full environmental consequences of the chemicals used for growing bananas (De la cruz and Castillo 2003).

Pesticides are used at all stages in the production of bananas, from the establishment of the plantation and the growing of the plants, through harvesting the fruits, packaging and exporting. There is no single source of data on the exact amount of pesticides used in each banana plantation. Following De la cruz and Castillo (2003:350) banana growers used more than 23.6% of the overall Costa Rican pesticide import. Moreover during the research period the overall use of pesticide for bananas grew from 1,600 metric tonnes in 1990 to around 2,500 in 2004.

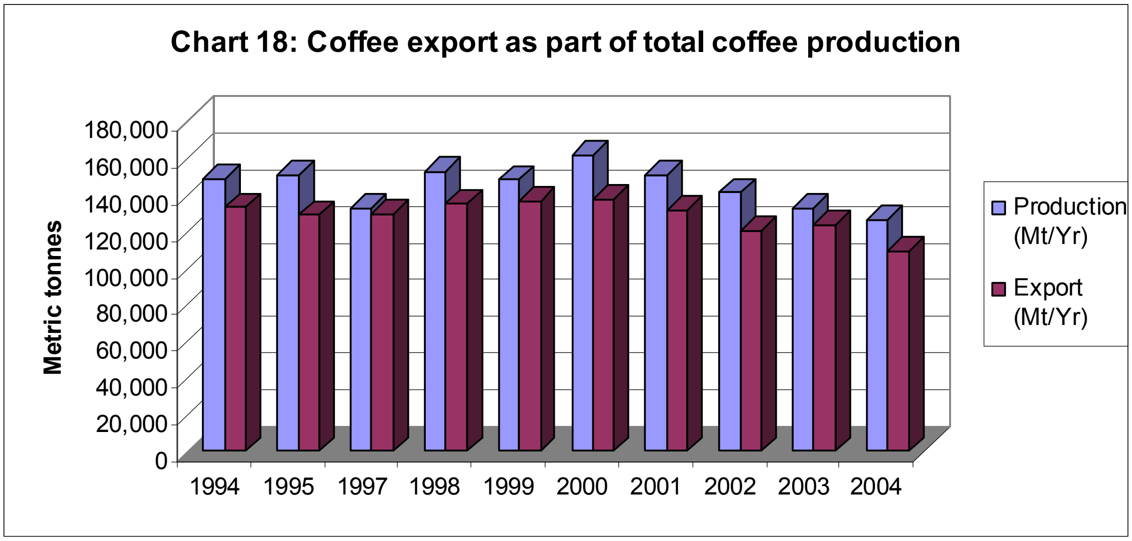
Different studies have estimated the annual use of pesticides per hectare of banana plantation from 35 kg of active ingredient (Von Duszeln 1988 as cited in Castillo et al. 2000:1942) to 45 kg (De la cruz and Castillo 2003:350); from 48 kg (Lustig, 2004) to 74 kg (Rainforest alliance 2000 as cited in Clay 2004:254). While the composition of these chemicals has changed within the last decade or so as a consequence of rising awareness and public critique, the total amount used has not decreased and based on the above sources, has probably increased. These pesticides are divided into several groups: Fungicides 60 kg / ha (account for 49% of pesticides used); insecticides 0.5 kg / ha (account for 20% of pesticides used); herbicides 2 kg / ha (account for 26% of pesticides used); and nematicides 11 kg / ha (Rainforest Alliance 2000 as cited in Clay 2004:254; Hernandez et al. 2000).

Most studies on the ecological consequences of these chemicals have been conducted outside of plantations due to a lack of cooperation from plantation owners. While soil and water contamination within the plantations are fairly obvious, more significant environmental consequences of banana production stem from the flow of waste materials beyond the plantations into other ecosystems (Hernandez 1996:252). Chemical residues have been detected not only in the out-flow rivers from plantations but also in more distant rivers, in local ground waters, and as far as coral reefs in the Caribbean sea (Cortes and Jimenez 2003:223). These residues have had a disastrous effect on wildlife that previously thrived in and around these waterways (Hernandez 1996:252; Henriques et al. 1997:94; Castillo et al. 2000:1948).

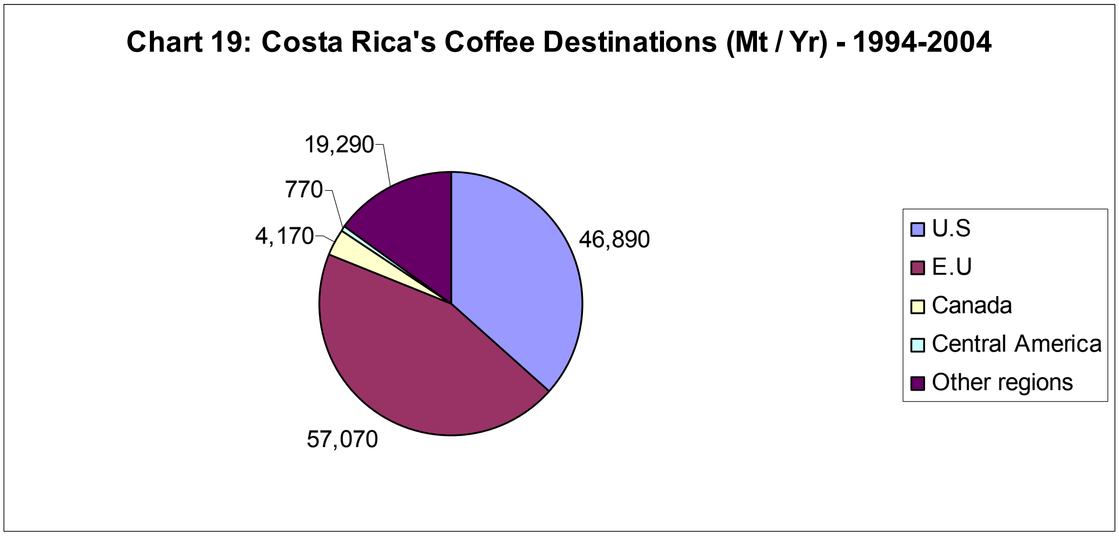
Chacon and Hernandez (1994: as cited in Hernandez 1996:253) study of water in streams surrounding several banana plantations revealed significant levels of multiple chemicals used in banana production. They also emphasize the lack of fish, insects or other animals in the study area as a result of these chemical residues. Castillo et al. (2000) conducted one of the most detailed studies of pesticide residues in banana plantation areas in Costa Rica during the 1990s. Their results showed extensive surface water contamination from pesticides used in banana plantations. The most widely distributed compounds found were fungicides (mostly propiconazole), and although the amounts found did not surpass aquatic quality criteria due to its relatively low toxicity, the total amounts and their combinations with other chemicals are still not clear (Castillo et al. 2000:1948). Other pesticide residues such as cadusafos, terbufos, chlorphyrifos, and diazinon were detected in maximum concentrations, likely causing acute toxicity, which over time creates chronic risk to aquatic organisms (Castillo et al. 2000:1949). The study revealed the existence of pesticide residues from banana cultivation as far as several km from the plantations in the waters of Tortuguero national park. This conservation area comprises about 20,000 ha and is a primary breeding ground for marine turtles. In addition, 60 species of amphibians, over 300 species of birds and numerous species of mammals have been documented in that park (Hernandez 1996). Pesticides that create water pollution could have direct and indirect effect on flora and fauna in the park and in other surrounding areas (Castillo et al. 2000:1949). The study also revealed six different pesticide residues within sediments, mostly near the plantations but also downstream. The potential for their transport with eroded particles should be considered, since pesticide residues in sediment can have a longer resistance time and thus imply an increased risk for surrounding ecosystems.

8.6.2 Coffee

Ever since Costa Rica's independence in 1821, coffee has been its economic backbone - the 'brown gold' (Seligson 1980). Coffee production has been a main source of employment. As a major export product it financed economic development and acted as a catalyst for the incorporation of other Costa Rican agricultural products into world trade. It generated between 60 and 90 percent of all foreign exchange earnings in the early part of the 20th century, about 30 percent during the 1970s and 80s and around 10 percent at the end of that century (Aguilar and Klocker 2000:595). As in the case of bananas, growing coffee in Costa Rica is strongly connected to international markets, government incentives, and internal and external interests (e.g., Seligson 1980; Williams 1994; Winson 1989). As in previous sections of this chapter the focus here is on the connections between coffee production and ecological changes in Costa Rica. Chart 18 presents Costa Rica's coffee exports as part of total coffee production.



On average within the research period 89% of coffee cultivated in Costa Rica was exported. Following the interregional model several countries have interest in coffee from Costa Rica and therefore in sustaining the supporting ecosystems that allow Costa Rica to produce and supply coffee. The following charts, 19 and 20, present the major export destinations of coffee within the study period, as well as the average weight and the size of the land in Costa Rica devoted to growing coffee for each destination.



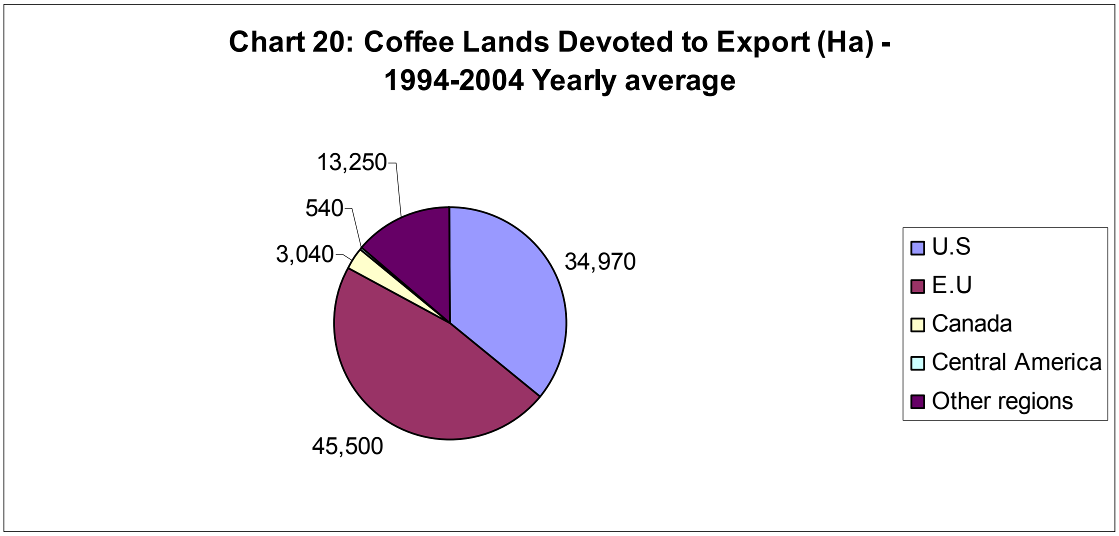


Chart 20: Coffee Lands Devoted to Export (Ha) - 1994-2004 Yearly average

This section traces the connections between coffee production and aspects of ecological change such as: habitat change, soil degradation, land and water contamination and biodiversity loss. The discussion covers different cultivation methods - shade and full sun, and the two major production phases –cultivating and processing. Each method and phase of production has direct and indirect impacts.

8.6.2.1 Coffee and habitat change

In terms of land use, coffee is Costa Rica's most intensive agricultural crop. On average within the research period more than 23% of Costa Rica's overall croplands or 43% of its permanent croplands were coffee lands. Also, a significant increase in size of the coffee lands has been documented from 48,890 Ha in 1950, to 113,390 Ha in 2004 (Sanchez 2000; FAOSTAT 2007). One of the most severe consequences of that intensive use of land for coffee production has been deforestation.

Coffee cultivation ranges from "traditional" to "modern" systems. The modern system is characterized by a reduction in shade, increased reliance on new high-yielding varieties, and an increase in chemical inputs, pruning, and coffee plant density (Wrigley 1988; Moguel and Toledo 1999). The removal of shade in coffee farms is aimed at increasing yields, at least over the short run. However, with the loss of canopy cover, modern plantations, also known as sun plantations, become more prone to water and soil runoff, threatening the long-term sustainability of the system (Perfecto et al. 1996). Coffee production in Costa Rica and its ecological implications can be divided into three major periods:

(1) *up to the 1950s* – This first century of coffee production is characterised by traditional coffee growing and processing practices. The expansion of the coffee sector in this period resulted in high levels of deforestation of primary forests (mostly in the central valley). Taylor (1980; as cited in Faber 1993:27) describes that period:

> "As the plantations expanded, they moved up the hillsides, displacing some of the finest forests of the region, first in the areas of rich volcanic soil and subsequently in the adjacent darker alluvial soils as well. The relative simplicity of clearing the land of trees and growing coffee also led many small farmers to clear the richly forested state lands away from the centre of the plateau".

However, coffee production in this period depended on the forest shade, and therefore any coffee led deforestation within that period was partial (Boyce et al. 1994). That traditional shaded coffee production while growing low yields used small amounts of external chemicals, and relative to more recent systems placed less pressure on eco-systems (Aguilar and Klocker 2000; Perfecto et al. 2005; Adams and Ghaly 2006).

(2) *1950s- 1990s* – At the beginning of the 1950s a new variety of coffee was introduced and became the major form of coffee production in Costa Rica. This new 'full sun' Arabica coffee (named 'Caturra') characterized by higher yields combined with the ideal physical conditions, made Costa Rica the world's highest yield per hectare coffee producer (Aguilar and Klocker 2000). It was mostly during the 1980s, however, that coffee plantations were increasingly 'technified' into large, monoculture plantations. Forest needed to be cleared to make room for these larger 'full sun' plantations, and the results were the complete deforestation of traditional partly forested plantations, deforestation of natural forests, and increased use of chemicals and energy (Aguilar and Klocker 2000; Varangis et al. 2003). Boyce et al. (1994 as cited in Perfecto et al. 1997:936) estimate that at the beginning of the 1990s 74% of the coffee farms where technified. According to Rice and Ward (1996:35) by the mid 90s' only 10% of Costa Rica's coffee plantations were traditional, another 40% were completely "technified" (i.e., mostly full sun plantations) and the remaining 50% were in an intermediate stage (i.e., partly shaded, using chemicals). In that period coffee plantations spread out of the central valley to other parts of the country but still the central region remained the major coffee production area, producing about 68% of the coffee (Sanchez 2000:493).

(3) *Since the 1990s* – Costa Rica's coffee production has been transformed into a monoculture system devoid of 90% of the flora and fauna found in the more traditional system (Adams and Ghaly 2006). About 96% of all new plantations have been "technified" – shade or sun coffee (Varangis et al. 2003; Adams and Ghaly 2006). New plantations planted within that period, while

mostly planted at the expense of other agricultural lands and not on naturally forested lands, use larger amount of chemicals. At the same time, rising production costs, ecological deterioration and rising consumer demands for more sustainable modes of production (e.g., organic, shade coffee) has increased in recent years the number and scope of plantations which combine natural vegetation and efforts to sustain the surrounding habitat.

Unfortunately, to my best knowledge, there are no empirical studies which provide data on coffee expansion and specific process of deforestation in Costa Rica. The above discussion of the three periods of Costa Rica's coffee cultivation, however, imply the extent of habitat change as a consequence of coffee expansion. Most documented coffee lands were previously natural forests; today some are completely deforested while other are still partly forest covered.

The connection between coffee and habitat change is found not only in the growing phase but indirectly in the processing phase as well. Coffee beans must be dried prior to their export; that process involves furnaces which use fire wood. Adams and Ghaly (2006:5) estimate that in Costa Rica the production of one tonne of green coffee involves 2.17 m_3 of fire wood. A rough estimation based on 2004 coffee production, indicates that more than 273,000 m3 of wood was required for that production. In the past the origins of this fire wood was surrounding forests, today it is mostly shade trees from coffee plantations, cut fruit trees from other plantations or waste wood from reforestation projects (Danse and Walters 2003).

8.6.2.2 Coffee and Soil degradation

The fertility and suitability of soil for coffee is determined by the physical, biological and chemical texture of the soil (Snoeck and Vaast 2004). Arabica coffee prefers a deep, well drained, loamy soil, slightly acid and rich in humus (Wrigley 1988:136). Soil depth should be at least 2 meters to allow root development and ensure the necessary water supply to the plant during the dry season (Descroix and Snoeck 2004). Organic matter contributes to the soil aeration and water retention capacity, which reduces physical soil erosion (Snoeck and Vaast 2004). That organic matter is composed of plant and animal residues at various stages of decomposition. Most of the organic matter is in the upper 30 cm layer of soil, representing up to 80% of the top soil in coffee areas (Snoeck and Vaast 2004).

The chemical composition, the nutrient availability, is also crucial for growing coffee. Without nitrogen coffee roots cannot develop; other nutrients such as calcium, magnesium and phosphorus are essential as well (Wrigley 1988:144). In Costa Rica the most suitable soils for coffee are volcanic soil formations; these 'Andisols' soils covers about 14% of the country and are concentrated in the central region (Betsch et al 2000).

Growing coffee deteriorates the physical, biological and chemical elements and therefore contributes to soil degradation. This degradation puts at risk future agricultural production, and it contributes to the sedimentation and pollution of nearby waterways, which jeopardizes other ecological systems.

<u>The physical erosion of the soil</u> - Although coffee, as a permanent crop stabilizes the soil much more than annual crops, it has been well acknowledged that growing coffee as a monoculture product (as most coffee is grown) is a major contributor to soil erosion (e.g., Clay 2004; Muschler 2004; Goodyear 2004). As a crop grown in hilly and mountainous regions, any gradient has the potential to increase rates of water run-off and physical erosion of soil (Goodyear 2004). In Costa Rica coffee is often grown on hilly and sloping lands and can reach a gradient of over 40% (Descroix and Snoeck 2004). Both deforestation and ground cover removal associated with the transformation of traditional shade coffee plantations to mono-crop systems contribute to soil erosion (Adams and Ghaly 2006).

Another reason for the physical erosion of soil is the use of herbicides. While the consequences of using different chemicals is discussed later on as a driver of land and water contamination, the use of herbicides (mainly Paraquat and Glifosato) to control weeds leads to a lack of soil coverage, which allows rain to wash away the fertile layer of soil more easily. According to Blanco and Perera (1999; as cited in Danse and Wolters 2004: 38), about 80 % of Costa Rica's plantations suffer from such soil erosion; on average within the study period that translates to approximately 88,000 ha of eroded coffee land. Beer (1985 as cited in Aguilar and Klocker 2000:604) estimated physical erosion rates of 366 kg/ha for six months of 'full sun' coffee growing, and 59 and 104 kg / ha for six months of growing two kinds of shaded coffee.

The biological and chemical degradation of the soil - The intensive use of land and its exposure to full sun deteriorate the biological contents of the soil. Lack of organic matter (especially in full sun plantations) reduces the humus contents; the soil becomes compacted and its aeration is reduced. These conditions result in a reduction of nutrient uptake by the coffee roots (Snoeck and Vaast 2004:373). According to Muschler (2004:399) the importance of soil organic matter is being increasingly recognized not only for nutrient release and retention, but also for the maintenance of an intact microbial community within the soil. The soil supports a large diverse community of microorganisms and harbors fungi and bacteria that act against pests and root diseases (Snoeck and Vaast 2004:373). Therefore, plant removal in coffee plantations combined with the use of chemicals to increase coffee yields, reduces the organic matter content of plantation soil and the diversity of microorganisms, all of which contributes to the biological erosion of the soil.

Coffee production in Costa Rica requires intensive land use. Over time the organic matter content of the soil is depleted and the mineral elements become unbalanced resulting in the chemical erosion of the soil. Chemical degradation impairs the development of coffee roots, makes the coffee trees more susceptible to pests and ultimately reduces coffee production and yields (Snoeck and Vaast 2004). To reach high yields of coffee production and to compensate for the loss of organic matter and of natural mineral contents, artificial fertilizers are used. ICAFE (1989 as cited in Aguilar and Klocker 2000:602) estimated that fertilizer use ranged between 500 to 1000 kg per ha / yr in Costa Rican coffee plantations. Nitrogen (N) is one of the major minerals that must be added artificially. The use of N fertilizers in rates of 100 – 300 kg / ha results with 10-50 kg N / ha lost by leaching (Aguilar and Klocker 2000; Snoeck and Vaast 2004). Following data from IFA-FAO (2002) on average the annual commercial fertilizers input for growing coffee in the research period was 53,000 metric tonnes. Moreover, the annual fertilizers use has increase from 52,500 Mt in 1989 to 56,600 in 2004.

8.6.2.3 Coffee and Land and water contamination

Coffee production generates high amounts of chemical and organic waste. That waste has the potential to impact other terrestrial and aquatic ecosystems. Unlike habitat change and soil erosion where the impacts are mostly at the cultivation phase, land and water contamination are a result of both the cultivation and processing phases.

The transformation from traditional shade coffee to ‘modern’ full sun or partially shaded plantations involved a significant increase in the use of chemicals (Aguilar and Klocker 2000). Fertilizers and pesticides have allowed Costa Rica to increase its yield for each unit of land; however, the attempt to maintain high yields of production over many years has also resulted in land and water contamination. While the use of fertilizers has been discussed above, pesticides have an important role as well. The use of pesticides in coffee production involves herbicides to eliminate weeds (mainly Paraquat and Glifosato), insecticides as well as fungicides.
According to De la Cruz and Castillo (2003:350) on average 6.5 kg / ha of active ingredient pesticides are used for coffee plantations in Costa Rica. Following that, I estimate an overall annual pesticide use of around 700 Mt.

Some of the pesticides used in coffee plantations leach into the ground water or can reach nearby streams. While coffee is mostly grown in the central region of the country pesticide residues have been found in coastal areas (De la Cruz and Castillo 2003). Coto (1993 as cited in Aguilar and Klocker 2000:605) estimates a total use of 213 tonnes of fungicides a year in the ‘Tarcoles’ river basin, where a large quantity of coffee is grown. While some chemical residues are the consequence of the cultivation phase, another portion reaches surrounding eco-systems as a result of coffee processing.

The coffee bean represents only 18% of the total biomass weight of the harvested coffee cherry. The other 82% are mostly considered waste (Adams and Ghaly 2006). Following Cleves (2004:717) and Adams and Ghaly (2006:5), production of one tonne of green coffee generates 3.4 tonnes of waste, of which 2.25 tonnes are pulp (0.4 tonne of dry matter), 0.9 tonnes are mucilage (0.2 tonne of dry matter) and 0.25 tonnes are husk (0.2 tonne of dry matter). Overall, Ulloa et al (2004:90) estimate Costa Rica’s yearly coffee waste at around 490,000 Mt.

Coffee processing involves large quantities of water (Chapagain and Hoekstra 2007). It has been estimated that the production of a single tonne of green coffee involves the use of 22 m3 of water (Adams and Ghaly 2006:5). Following the average yearly coffee production within the study period, processing coffee in Costa Rica uses an estimated yearly amount of 3,251,200 m3 of water. Until the 1990s that water used to be discharged into the nearest creek without any treatment, carrying a large amount of pulp and other solid waste (Danse and Walters 2003). That waste included chemical residues as well; Adams and Ghaly (2006:5) estimate that each litre of water discharges up to 248 mg of nitrogen residue, 13 mg of phosphorous and 268 mg of potassium. Moreover, the water COD (chemical oxygen demand) is 18,000 mg per litre; for comparison, wastewater standards in Europe allow waste water to be discharged back to the environment at a maximum rate of 1,000 mg per litre (Pupunat et al. 2002).

Costa Rica’s Tropical Science Centre (TSC 1982 as cited in Aguilar and Klocker 2000:605) estimated average daily discharges of 276 tonnes of wastewater from coffee production; more than double that of all other industrial and household waste at that time. Furthermore, most coffee processing takes place in the dry season when rivers are at their lower levels when the discharge of large amounts of water with high COD results in anoxic areas that affect the density and diversity of aquatic fauna and nearby flora. The impacts reach as far as the Pacific Ocean (Danse and Walters 2003). Since the mid 1990s new regulations have attempted to address land and water contamination problems: most solid waste is being collected and about 25% of it is used, mostly as an organic fertilizer (Ulloa et al. 2004:90). Coffee producers must treat water before it returns to the river; they use simple waste-water treatment systems based on a number of basins through which the polluted water passes before it flows back to the river (Danse and Walters 2003). While these new regulations have improved the state of surrounding aquatic ecosystems, a significant amount of residue is still discharged after minimal or no treatment (Adams and Ghaly 2006).

8.6.2.4 Coffee and Biodiversity loss

One of the consequences of habitat change, soil degradation and land and water contamination associated with coffee production, is biodiversity loss. In recent years the connection between coffee cultivation and biodiversity loss has received increasing attention from biologists and conservationists (e.g., Perfecto et al. 1996; 1997; 2005; Rice and Ward 1996; Ricketts 2004; Ricketts et al. 2004). Unlike many other agricultural products coffee has the potential to sustain some of the forest's natural biodiversity (Perfecto et al. 1997; Moguel and Toledo 1999); however, its 'technification' into a monoculture product means that coffee production leads to increased biodiversity loss (Vandermeer and Perfecto 2005).

Some of the connections between coffee cultivation and biodiversity loss have been documented in studies that focus on the differences between traditional shaded coffee and modern monoculture, shade or full sun coffee production. Several studies have shown that a forested traditional coffee farm retains the vast majority of bird species and most of the microorganisms, insects, and mammals that are found in natural rainforest (e.g. Perfecto et al. 1996; Rice and Ward 1996; Moguel and Toledo 1999). At the same time those studies emphasize the strong correlation between modern monoculture shaded and especially full sun cultivation and biodiversity loss.

All comparisons between sun and shaded plantations have shown a decrease in biodiversity with the conversion from shade to full sun plantations. The loss of forest in coffee plantations, aside from reducing the diversity of flora itself, also means a loss of resources for many species in the food chain. According to Beer (1988) shaded plantations in Costa Rica produce between 5,000 and 20,000 kg ha /yr of leaf litter and pruning residues, essential for the survival of several species. Shaded plantations, particularly rustic ones, contain old and dead trees that provide habitat for a large biodiversity, habitat that is cleared in the shift to full sun coffee cultivation. As a result of clearing, fluctuations of temperature and humidity become more extreme and affect the resilience of different species. Moreover, the use of chemicals in the modern coffee plantations jeopardizes biodiversity. While the shade of traditional plantations reduces weed growth, full sun cultivation requires intense herbicide applications to reduce the ground cover of grasses. Insecticides as well as certain fungicides are known to decrease biological diversity in agro ecosystems (Perfecto et al. 1996).

Perfecto et al. (1997) studied biodiversity in different coffee plantations in Costa Rica's central valley. Their study focused on arthropod biodiversity in the ground strata and tree canopy. They showed that arthropod diversity was lower in the ground strata of monoculture shade farms and full sun monoculture than in that of traditional shaded canopy. For example the average number of ant species per tree collected in the monoculture shade plantation (5 species) was 78% lower than the number (22 species) collected from the traditional plantation. In another study Perfecto and Snelling (1995) surveyed ant species diversity and found a positive correlation between species diversity and vegetation complexity. Once again, the highest diversity was found in the traditional farm and the lowest in sun coffee plantations. They found that in a shaded plantation in Costa Rica, on average 72% of ants were found exclusively in trees. The entomological laboratory of the University of Costa Rica studied arboreal arthropod fauna in coffee plantations (as cited in Vandermeer and Perfecto 2005:153), they found 373 species in traditional shade coffee plantation compare to 184 in intensively managed plantation and only 75 species in full sun plantation. These are significant results given the amount of coffee lands in that country, and the increasing of the area of full sun coffee plantations in recent years.

Traditional coffee plantations are described as supporting a large diversity of migratory birds (Rice and Ward 1996; Moguel and Toledo 1999). Most observers have noted that the high abundance and diversity of birds in coffee plantations is associated primarily with the tree canopies (Moguel and Toledo 1999). Greenberg et al. (1997) determined that the density and diversity of birds in sun coffee plantations is approximately half that in traditional coffee plantations. Three largely migratory songbird species are probably the most specialized migratory species on shaded plantations: the Baltimore oriole and the Tennessee warbler in Mesoamerica, and the Cape May warbler (Dendroica tigrina) in the Antilles. Data from the Breeding Bird Survey of the US National Biological Service (as cited in Rice and Ward 1996) indicates that all three species have experienced sharp and statistically significant population declines from 1980 to 1994, corresponding to the period of intense coffee modernization. Finally, Gallina et al. (1992; as cited from perfecto et al 1986) estimated that approximately half of the species diversity of non flying mammals is lost due to coffee conversion. An even higher percentage of reptile and amphibian diversity appears to be lost as well (Seib 1986; as cited from perfecto et al 1996).

8.6.3 Beef

Livestock was first introduced to Costa Rica in the mid 16th century by Spanish colonizers (Hall et al. 2000a). However, it is since the mid 20th century that cattle stocks increased significantly and beef started to be produced commercially (Ibrahim et al. 2000). Hall et al. (2000:29) present several conditions that made Costa Rica attractive for that expansion: (1) Costa Rica had a relatively small population and an abundant supply of land (although at that time still mostly forested). (2) Costa Ricans already had the required experience in growing cattle as well as several herds scattered across the country, mostly at the Nicoya region. (3) An aggressive and relatively high yielding African pasture grass, called jaragua, was introduced into the area in the 1920s and grew well in many places. Combining these conditions with external demand, international meat prices and government incentives drove the expansion of the Costa Rican cattle industry (Brockett and Gottfried 2002; Evans 1999; Lutz and Daly 1991; Myers 1981).

> “With these resources it is not surprising that the availability of an export market and large amounts of capital would transform the [Costa Rican] forest into pasture” (Meehan and Whiteford; 1985 as cited from Hall et al. 2000a:29).
>
> “The expansion of cattle pasture [in Costa Rica] was driven by increased U.S. demand for low grade beef and by financing of cattle expansion by the international development banks in an effort to diversify Costa Rican exports beyond coffee and bananas” (Schelhas 1991).

Unlike bananas and coffee, where most of the production has been devoted to export, the case of beef is more complicated. In the past export was a major driver for beef production, but in recent years, lower prices and increasing awareness of ecological implications resulted in an overall reduction of beef production in Costa Rica and specifically for export (Benavides 2005).

Again, the focus of my research is on connections between beef production and ecological changes. The connections documented here are habitat change and soil degradation. Land and water contamination and biodiversity loss are also potentially linked to beef production but due to a lack of data, these links could not be documented in my research. As some of the ecological changes associated with beef production occurred in the past, I am extending the research data timeframe in order to capture those changes and relate them to the interregional ecology approach. Chart 21 shows beef production and the pastureland devoted to that production in selected years from 1960 to 2004. Chart 22 shows the proportion of cattle slaughtered for overseas versus local consumption. Chart 23 present the land area devoted to growing beef for export.

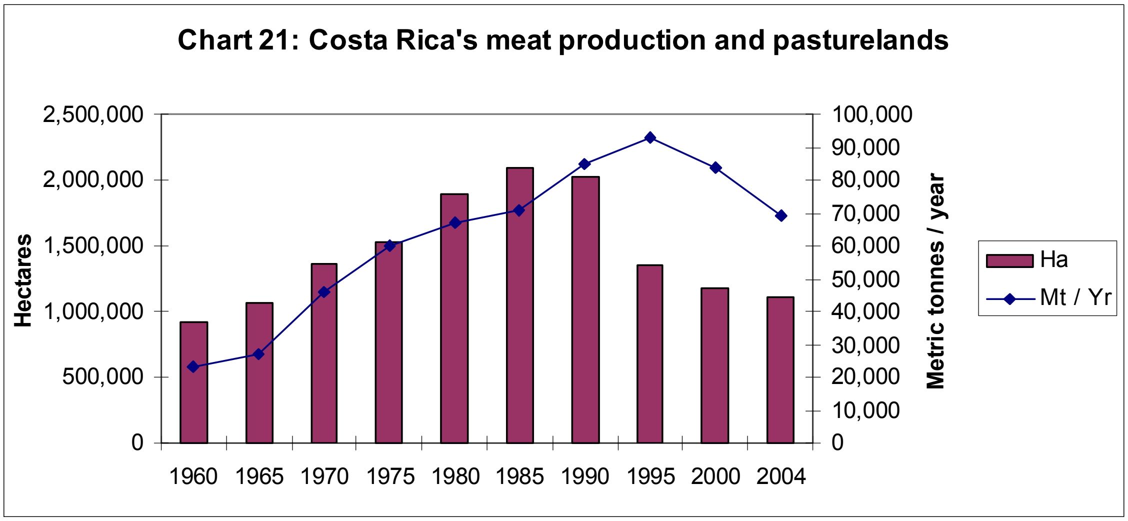


Chart 21: Costa Rica's meat production and pasturelands
Hectares
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Metric tonnes / year
Ha
Mt / Yr
1960
1965
1970
1975
1980
1985
1990
1995
2000
2004

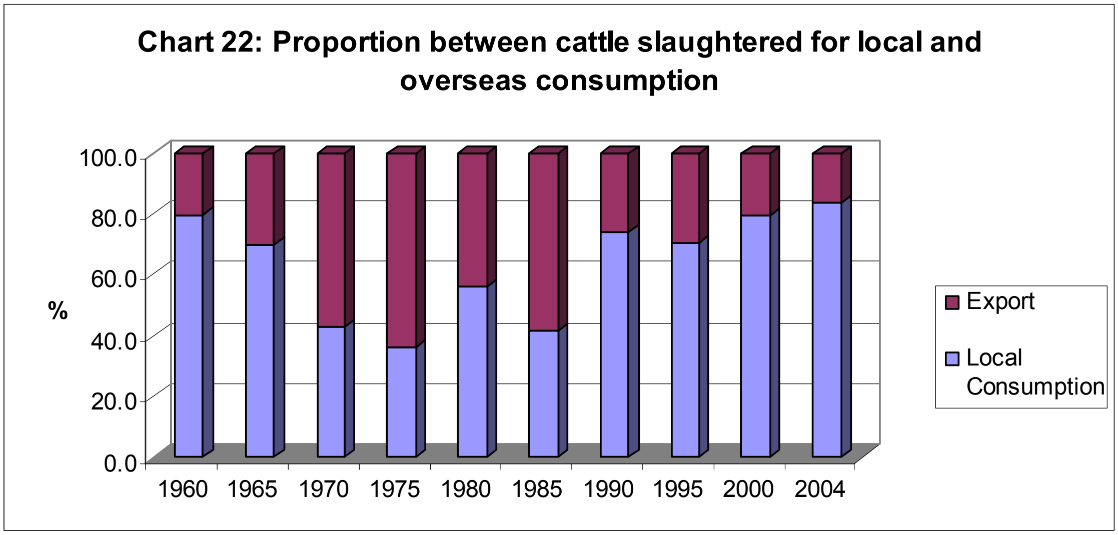


Chart 22: Proportion between cattle slaughtered for local and overseas consumption
%
100.0
80.0
60.0
40.0
20.0
0.0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2004
Export
Local Consumption

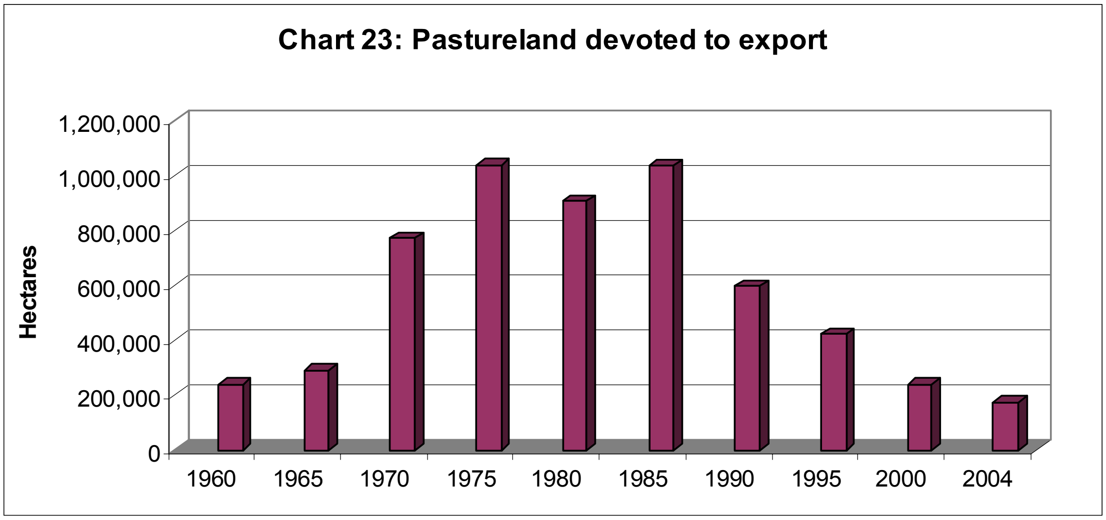


Chart 23: Pastureland devoted to export
Hectares
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2004

Table 29 summarizes the data on Costa Rica's average yearly livestock, meat production, pasture land, beef export, and the amount of pasture land devoted to export within the last several decades. The two major export destinations of Costa Rican beef have always been the U.S. and other neighboring Central American countries; only small amounts are exported to other destinations (for more detailed data please see appendix 2 table 8).

Table 29: Costa Rica's yearly average beef production, export and required pastureland

	Beef cattle numbers[30]	Pastureland[31]	Meat production[3]	Meat export	Equivalent livestock exported	Export out of production	Exported pasture land
	No	Ha	Mt	Mt	No	%	Ha
1960 – 1965	1,045,000	960,000	25,000	8,160	47,290	32.2	232,470
1966 – 1970	1,391,000	1,238,600	36,400	19,800	100,130	53.3	666,260
1971 – 1975	1,660,000	1,505,200	53,400	33,800	174,170	63.1	954,400
1976 – 1980	1,945,200	1,862,000	74,400	41,800	205,340	56.1	1,041,280
1981 – 1985	2,017,600	2,186,800	91,200	35,400	174,640	40.1	877,220
1986 – 1990	1,531,800	2,334,000	81,000	32,800	161,900	42.4	986,200
1991 – 1995	1,168,400	2,340,000	91,600	30,800	150,100	26.8	787,180
1996 – 2000	1,063,600	2,141,900	84,200	18,600	86,450	21.9	471,810
2001 - 2004	1,150,500	1,349,600	73,500	11,000	47,280	15.0	201,940

As presented in Table 29 as well as in charts 24-26, from the 1960s to the mid 1980s beef cattle numbers almost doubled and drove pastureland expansion as well, an expansion that continued until the mid 1990s. Meat and livestock exports increased significantly during the 1970s and continued to be high until the mid 1980s (reaching its peak at 1986). While production and exports have decreased ever since, a significant amount of pastureland is still devoted to growing beef cattle for export. The figures also suggest that local meat consumption is increasing. That increase partially reflects a change in the Costa Rican standard of living (Kaimovitz 1996). Moreover, internal consumption of beef products can be connected to the increased flow of tourists into Costa Rica in recent years. Tourism has become a leading economic sector and consumes large quantities of beef products (Ibrahim et al. 2000:443).

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[30] USDA 2007; FAOSTAT 2007; MAG 2006; Ibrahim et al. 2000

[31] FAOSTAT 2007; MAG 2006; Ibrahim et al. 2000

8.6.3.1 Beef and habitat change

It is agreed upon by all researchers that in Costa Rica increased production of beef led to significant processes of habitat change (e.g., Kaimowitz 1996; Hall et al. 2000a; Sanchez-Azofeifa 2000; Camino et al. 2000; Ibrahim et al. 2000). By the mid 1990s pasturelands occupied 54% of all agricultural land and 44% of total land mass (Hall et al 2000a:29).

From the 1960s to 1980s Costa Rica's beef livestock had increased by a factor of 2.7 (from 901,000 head to 2,465,000 head). At the same time the equivalent number of cattle slaughtered for beef export had increased by a factor of 8.7 (27,270 head in 1960 to 237,000 head in 1986). As presented in Figure 16 above, from 1970 to the mid 1980s more than 50% of production was for export. That increase led to the expansion of pastureland.

Pastureland had annually expanded by 4.1% from 915,000 Ha in 1960 to 1,558,000 in 1973 (Ibrahim et al. 2000:426; Sanchez-Azofeifa 2000:480). A significant portion of that expansion led directly and indirectly to deforestation. During that period more than 450,000 ha of natural forest were converted into pasturelands. An additional 150,000 ha of cropland were converted to pastureland, lands that were deforested several years before for other agricultural activities (Sanchez-Azofeifa 2000:489). In the following years pasturelands continued to expand, reaching 2,340,000 ha in the mid 1990s (MAG 2005). According to the Costa Rican Ministry of the Environment (MINEA 1996: as cited in Camino et al. 2000) between 1979 and 1992 an overall of 724,350 ha of forest were converted to pastureland; from which 322,520 ha were natural forests and 401,830 ha were secondary forests. At the same time they estimated 105,490 ha of pastureland were reforested and another 95,100 ha converted to different croplands (Camino et al. 2000:7). Since the mid 1990s, the decline in cattle populations has resulted in a decrease in pastureland; large areas of land have been abandoned and some reforested. Currently, the pastureland is estimated at 1,349,630 ha (MAG 2005).

The following paragraphs discuss some of the drivers and consequences of pastureland soil degradation. While habitat change leads to soil degradation such degradation accelerates habitat change as well. Ranchers often prefer to deforest new areas to take advantage of their initially high fertility levels, rather than recover recently abandoned pastures which may have lower fertility (Kaimowitz 1996). Buschbacher (1986) has described this process as "shifting ranching". Wassenaar et al. (2007:9) support that finding and estimate that between 2000 and 2010 an additional 59,000 ha of forest in Costa Rica will be converted to pastureland – most will be small forest patches within pasture areas.

8.6.3.2 Beef and soil degradation

Beef production is a major driver of soil degradation. In Costa Rica as in other Central American countries much of the pasturelands are poorly adapted for cattle-grazing (Kaimovitz 1996). The conversion of forests to pasturelands increases soil compaction, temperature variations and dry winds; it also decreases relative humidity, water infiltration and organic matter in the upper soil; all lead to erosion of the soils (Ledec 1992). Ibrahim et al. (2000:436) have estimated that in Costa Rica more than 70% of the pasturelands are in an advanced stage of degradation. Rubin and Hyman (2000:460) estimated physical soil erosion in Costa Rica's pasturelands at 4.2 tonnes / ha / yr. Based on the current size of Costa Rica's pastureland, over 5.6 million tonnes of soil are eroded every year. However, the combination of high amounts of precipitation and high cattle concentration on hillsides makes that physical erosion even worse. Flores (1994; as cited in Ibrahim et al. 2000:437) estimated soil loses of 50 tonnes / ha / yr in sloping areas, resulting in 250 tonnes of soil lost for every tonne of beef produced.

A Hirvela *et al.* (1989; as cited in Kaimovitz 1996:57) study in neighboring Nicaragua, found that while in 1977 about 50% of the pastureland was considered in "good pasture" condition, ten years later in 1987 only 35% of the land could be considered "good pasture". That process is typical for pasture all over the tropical region. When forests are cleared for pasture the soil is rich with nutrients, however due to leaching, runoff, uptake by the pasture plants, and incorporation into the cattle soil, nutrients rapidly decline to levels below those necessary for maintaining pasture production (Hecht 1993).

Soil compaction is a major driver of pastureland degradation (Kaimovitz 1996; Ibrahim et al. 2000). It is a result of a combination between high rates of precipitations on open pasturelands, the texture of the soil (high peat, clay and silt) and over grazing. The compaction of the soil reduces its aeration, which reduces root development and biodiversity in the soil, resulting in a reduction of vegetation and thus accelerating physical erosion (Steinfeld et al. 2006). Another driver for soil degradation is the lack of grass species adapted to pastureland in Costa Rica. In the 1970s grass species were imported in an attempt to increase yields and to reduce soil degradation. While these species grew very well they required high rates of nutrients which led to chemical degradation of the soil (Ibrahim et al. 2000:437).

8.6.3.3 Land and water contamination:

Growing livestock and producing beef contaminate surrounding land and aquatic ecosystems both directly and indirectly (Steinfeld et al. 2006). The direct contamination can be divided into point and non-point sources of pollution; it involves the physical outputs of growing cattle and processing beef. On the other hand indirect contamination is connected to chemical inputs involved in growing pasture (Steinfeld et al. 2006).

Benavides (2005) studied the impact of pasturelands on river chemical pollution at the Nosara basin in North Western Costa Rica. He found that going from a watershed that is totally forested to one that is totally under pasture increases the concentration of sediment at the river outlet by approximately 5 times (at 600 mg / L); the nitrogen by 3.5 times (at 6 mg / L) and phosphorus by 8 times (at 1.8 mg / L). The U.S. Environmental Protection Agency (2005; as cited in Benavides 2005:57) recommends maximum concentrations of suspended solids in the range of 25 – 100 mg/L for recreational waters, primarily with the intention of protecting aquatic life. The sediment concentration found was significantly higher than the recommended maximum limits. In the case of nitrogen concentrations, the USEPA short term standards for drinking water are 11 mg / L. On the other hand, the World Health Organization's long term exposure standard is 0.2 mg / L (WHO; 2004 as cited in Benavides 2005:58). While nitrogen concentrations found in the research are lower than the short term standard, they are significantly higher than the long term exposure standard.

De La Cruz and Castillo (2003:350) have estimated the amount of pesticide involved in growing pasture in Costa Rica at 0.25 kg of active ingredient per ha. While this is a relatively small amount compared to other products (e.g., 45 for bananas or 6.5 for coffee) the overall use of pesticides for pasturelands estimated at a total of 391 Mt. is significant due to the size of those lands.

8.7 Summary

The goal of this chapter was to illuminate the interregional ecological connections between Costa Rica and other regions of the world, to document the linkages between ecological change in Costa Rica and production for consumption in other regions of the world. The focus has been on the agricultural sector. I have included most of Costa Rica's agricultural products, documented the physical inputs involved with their production, and made some linkages between growing / producing three major products to the overall ecological changes Costa Rica has experienced over the last several decades.

Overall the chapter reveals that on average in the research period almost 55% of agricultural crops grown and 25% of beef production were exported. That production involved an average of 48% of croplands or 30% of the overall Costa Rican agricultural land (crops and pasture). Moreover, the eight major export crops (bananas, cassava, coffee, melons, oil palms, oranges, pineapples, and sugar) used an annual average of 89% and more than 50% of Costa Rican fertilizers and pesticide respectively.

One of the most significant ecological changes has been loss of habitat (mostly as a consequence of deforestation). Between 1940 and 1990 the forest areas declined from covering around 70% of Costa Rica's territory to about 30%. Despite an increasing number of reforestation projects in recent years, between 1990 and 2000, a decrease of about 10% in natural forests was recorded. This process of deforestation combined with inappropriate use of the land led to depletion of the soil. Between 40-60% of Costa Rica's lands suffer from deteriorating soil conditions. Deforestation together with soil degradation and the use of toxic chemicals accelerated the loss of biodiversity as well.

As documented in this chapter, agricultural activities (annual and permanent crops and beef production) have played a major role in those processes of ecological change. Given that a large portion of that production has been devoted to export the correlation is clear. As discussed in detail, the three products examined here: bananas, coffee and beef played, and continue to play, a major role in the processes of land degradation and overall ecological changes in Costa Rica – each production leads to impacts such as the loss of habitat, soil degradation, water contamination and biodiversity loss. In summary by the beginning of the 1990s pasture land covered an area of more than 2,340,000 ha, a large portion of which were previously forest land. By the late 1990s bananas occupied about 56,700 ha mostly on land converted from pristine forest. Over the same period coffee production occupied areas of 114,000 ha; a large portion of this area was acquired through deforestation. As also documented in this chapter, on top of deforestation, the production of beef, bananas and coffee also led to soil erosion, water and land contamination and biodiversity loss.

Looking at ecological change from the interregional perspective presented here can provide consumers as well as their governments with feedback from supporting ecosystems; feedback that usually does not reach them. The feedback generated by the interregional approach can stimulate policy that will incorporate the consequences of producing specific import products, and can lead to more sustainable production and consumption patterns.

In 1981 Norman Myers coined the phrase the ‘Hamburger connection’ – the connections between North American meat consumption and deforestation processes in Central America. In the concluding paragraph of his paper he wrote:

> “It is clear that both Central Americans and North Americans are contributing to the ‘hamburgerization’ of the rain forests, and that both will suffer from the loss of them. It is equally clear that both must cooperate if the problem is to be solved: either all will lose together or all could gain together – a paradigm of interdependency resource relationships within the international community” (Myers 1981:8).

Following the interregional approach, the sustainability of Costa Rica should be of interest not only to Costa Ricans but also to millions of consumers who eat and drink Costa Rica’s products, and many more who receive ecological services from this unique region of our world.

Chapter IX -

Consuming Canada - an interregional ecology approach to ecological change in the Canadian Prairies

9.1 The national scale

9.1.1 Introduction

Canada, the world's second largest country, covers approximately 10 million km2, extends 5,500 km between the Atlantic and Pacific Oceans and 4,600 km north from the United States border (Natural resources Canada 2004). Canada comprises a mosaic of 15 distinctive terrestrial eco-zones ranging from the Atlantic maritime in the east, through the prairies and montane cordillera of the west, and from the northern arctic archipelago south through the vast boreal shield to the Carolinian Zone in southern Ontario (Environment Canada 2007). Despite its size, only 5% of Canada's terrestrial area (about 46 million Ha) can be used for agricultural crop production and only 0.5% considered to be prime agricultural croplands (Canada's land inventory 1978).

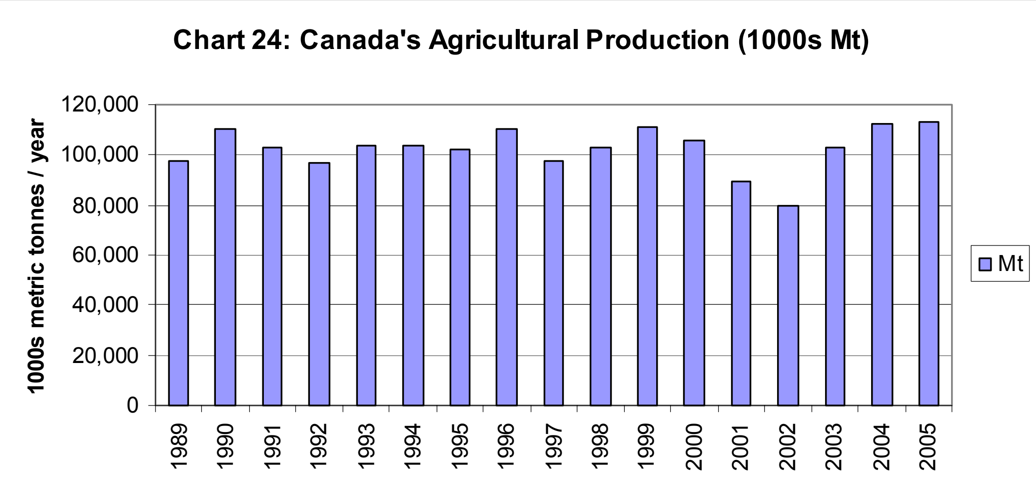
As presented in chapter VII, the U.S. and Canada have strong interregional connections; a large portion of the United States' external footprint falls on Canada. However, as this chapter will show, an increasing amount of Canadian production is devoted to consumption in countries other than the U.S.

This chapter is divided into two major sections exploring the interregional connections of several regions with Canada. In the first section I document the production and trade flow of Canada's 45 major agricultural crops as well as cattle livestock and beef products (see table 4 in chapter 'VII'). This section captures the production weight *of agricultural goods* and examines four of the physical inputs involved in production – land, water, chemicals and energy – between 1989 and 2005. In the second section I investigate some of the linkages between agricultural production (mainly for export) and processes of ecological change with a focus on the Canadian Prairies.

9.1.2 Canada's agricultural production

Following conventional economic indicators (e.g., GDP, employment rates) one might conclude that the Canadian agricultural sector, which played a major role in Canada's development, is no longer of great economic importance. According to Statistics Canada (2007a:18), the agricultural sector employed 18% of the Canadian work force in 1955 but only 1.8% in 2007. Agriculture's contribution to GDP has also declined, from 6.4% in 1955 to only 1.3% today (FTP 2006:9). Decreases in agriculture's proportion of labour and GDP can be linked to relatively stronger growth of other sectors in the Canadian economy, new technologies that reduce demand for labour and the shift from family farming to large industrial farming in many parts of the country. Agricultural production, however, has actually increased significantly and continues to do so, both in terms of value, which has tripled since the 1960s (Agriculture Canada 2006), and volume. As agricultural production and exports increase, more people both within Canada and abroad become dependent on Canada's agricultural production as a major source of a wide variety of food products.

Canada has 67,586,700 ha, of farmland including 35,912,200 ha of croplands and 21,136,000 ha of natural and seeded pasture (STATCAN-COA 2007)[32]. Chart 24 presents the overall weight fluctuations of agricultural products studied here.



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[32] The rest of the farm land includes 3,505,570 Ha of summer fallow and 7,032,930 Ha of other land use.

9.1.2.1 Agricultural crops

Grains are the major agricultural crops grown in Canada, representing an average of 56.3% by weight of overall crop production within the research period, followed by hay (25.6%) and oil seeds (8.5%). However, the proportions of major crops represented in the total shifted: grains represented 57.1% of the overall production weight in 1989 but dropped to 53.4% in 2005 while oil crops which represented only 5.0% of production weight in 1989 increased to 10.8% in 2005 (Chart 25 and Table 30; see appendix 3 table 1 for complete data). Table 31 presents the physical inputs involved in production within the research period and chart 26 the composition of land devoted to specific agricultural product groups.

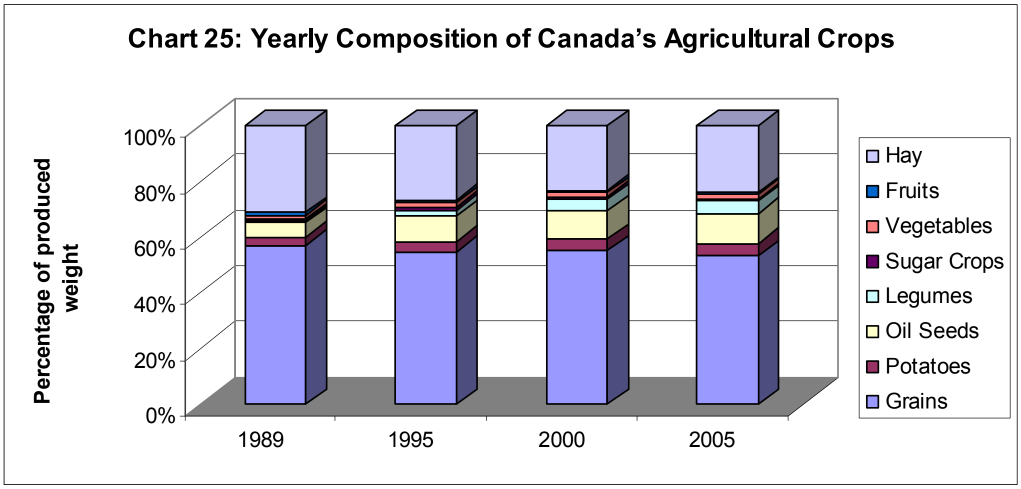

Table 30: Canada's agricultural production by major product groups

	1989	1995	2000	2005	Average annual change
	Mt / Yr	Mt / Yr	Mt / Yr	Mt / Yr	+/- %
Grains	55,150,900	55,239,200	57,024,000	59,636,700	+ 1.2
Potatoes	2,876,400	3,834,000	4,567,300	4,850,000	+ 3.7 %
Oil Seed	4,835,900	9,262,700	10,526,600	12,067,500	+ 7.7 %
Legumes	556,300	2,228,500	4,587,600	4,872,700	+ 17.3 %
Sugar crops	828,000	1,026,900	821,000	720,000	+ 4.0 %
Vegetables	1,450,200	1,644,100	1,765,400	2,093,500	+ 2.5 %
Fruits	747,500	861,900	806,000	704,100	+ 0.1 %
Tame hay & fodder corn	36,701,300	31,846,700	29,812,300	34,098,400	+ 0.1
Others[33]	75,600	74,200	53,000	43,000	- 2.6 %
Total	**96,521,500**	**101,022,500**	**104,396,100**	**111,616,800**	**+1.5 %**

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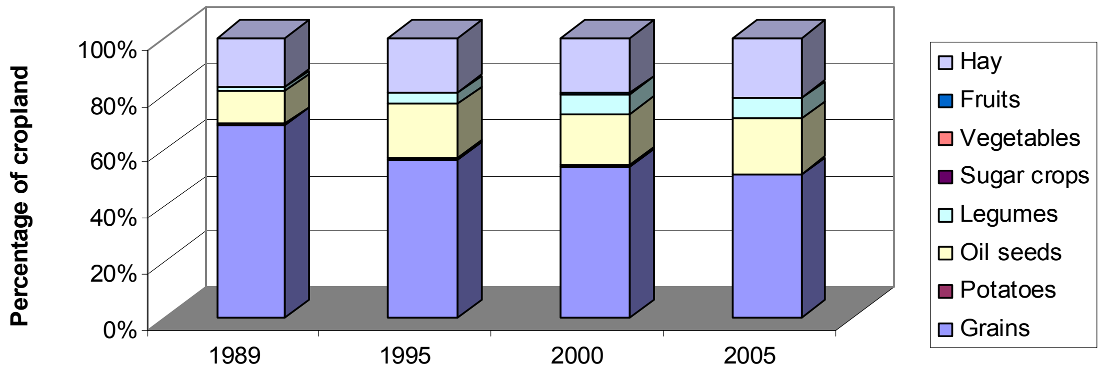
[33] Includes – tobacco, triticale, caraway seeds, and coriander seeds.

Table 31: Physical inputs to agricultural production

		1989	1992	1995	1998	2001	2005
Land[34]	Ha	32,664,220	31,234,780	33,387,080	34,102,840	33,103,860	34,101,750
Water[35]	1000s M3	72,655,600	79,841,500	86,825,800	92,453,796	73,490,800	97,956,000
Fertilizers[36]	Mt	2,130,680	2,155,740	2,387,000	2,728,200	2,523,350	2,798,400
Pesticides[37]	Mt	41,680	N/A	69,230	N/A	N/A	N/A
Energy[38]	Terajouls	200,430	196,770	209,170	224,630	218,040	208,310

Chart 26: Yearly composition of Canada's land devoted to agricultural crops



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[34] Calculated based on data from: Statistics Canada 2006; CANSIM II (2007); FAOSTAT 2006; The figures presented here not include pasture land.

[35] Calculated based on data from: Chapagain, A.K. and Hoekstra, A.Y. (2004) '*Water footprints of nations*' @ www.waterfootprint.org.

[36] Include Nutrient content weight of the major commercial fertilizers (Nitrogen, Phosphate, and Potash). Sources: Agriculture Canada (2003) Canadian Fertilizer Consumption shipments and trade. Canadian Fertilizers institute (2007) Canadian Fertilizers information system. FAOSTAT 2007.

[37] Environment Canada (2005) Pesticide utilization in Canada: a compilation of current sales and use data

[38] CANSIM II – Serious V618686, Canada's agricultural sector supply and demand of primary and secondary energy in Terajoules.

9.1.2.2 Cattle and beef production

Beef production increased from 9,590,400 head in 1989 to 14,017,000 in 2005 and from 951,930 Mt of processed beef in 1989 to 1,530,000 Mt in 2005 (Chart 30).[39,40]

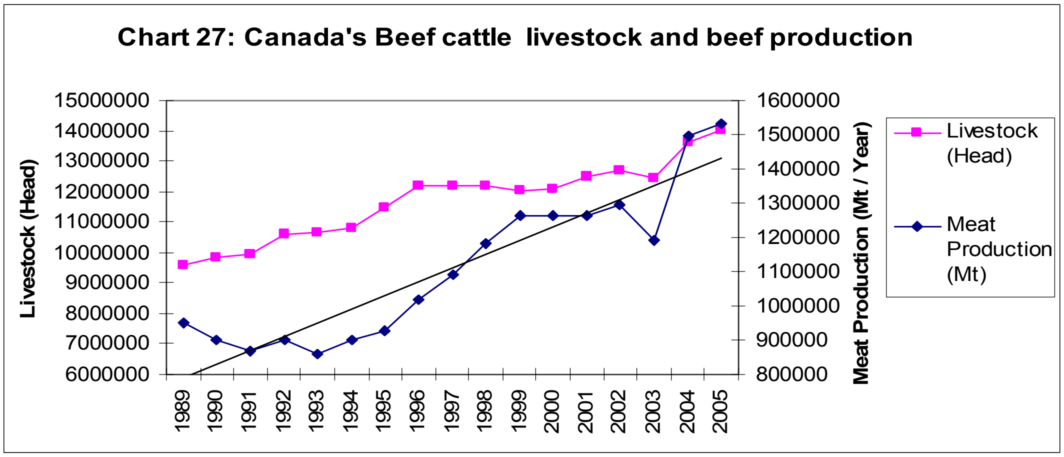
Chart 27: Canada's Beef cattle livestock and beef production

The physical inputs for livestock production include natural and seeded pasture as well as large quantities of animal feed (grains and tame hay). I focus on beef cattle which use more than 97% of Canadian pasturelands (Statistics Canada 2007b; 2003). On average during the research period, 41.2% of Canada's farmland was devoted to growing beef - 27.8% in pasture lands and 13.4% in cropland to produce feed (26.9% of all cropland)[41]. Table 32 summarizes the feed inputs for beef in Canada[42]

Table 32: Canada's beef livestock feed (metric tons/year)

	1989	1995	2000	2005
Wheat	142,800	175,700	183,800	212,500
Oats	1,523,300	1,874,200	1,961,000	2,266,200
Barley	3,351,300	4,123,200	4,314,200	4,985,700
Maize	790,200	972,200	1,017,300	1,175,600
Peas	85,700	105,400	110,300	127,500
Soy meal	219,000	269,400	281,900	325,800
Canola meal	133,300	164,000	171,600	198,300
Hay	9,777,900	12,030,000	12,587,100	14,546,400
Silage	6,064,800	7,461,600	7,807,200	9,022,500
Other roughage	2,523,000	3,104,100	3,247,900	3,753,500
Total	**24,611,300**	**30,279,900**	**31,682,300**	**36,613,900**

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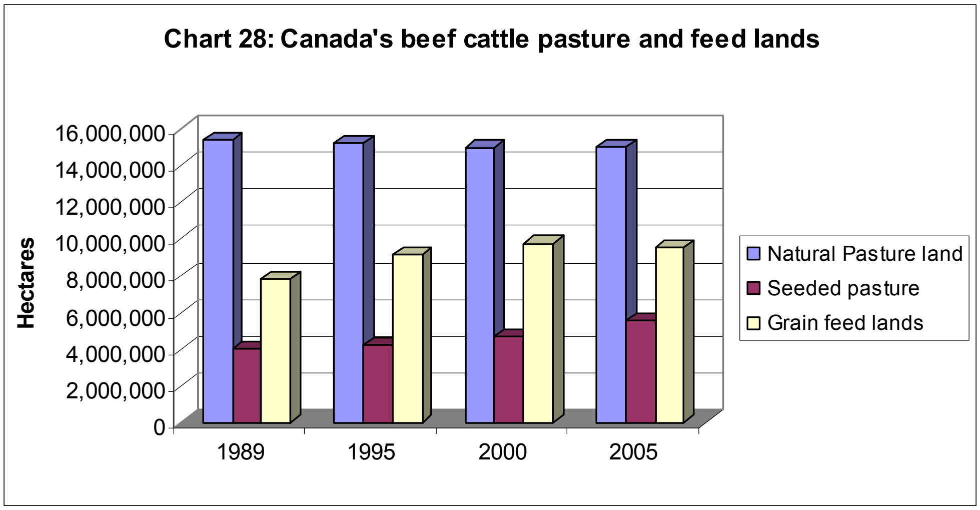
[39] Chart 1 includes agriculture crops as well as beef production; sources: Statistics Canada 2006; Agriculture Canada 2006; FAOSTAT 2006.

[40] Statistics Canada (2007) Cattle statistics Catalogue no. 23-012-XIE, Vol. 6, No. 1

[41] Data on overall farmland, natural and seeded pasture land (Statistics Canada Census of Agriculture 2006); Data on fodder lands (CANSIM Tables V169654, v169593) and grain for feed lands (Statistics Canada (2003) Livestock feed requirement study 1999-2001. 23-501-XIE).

[42] It covers most sources of beef livestock feed beyond natural pasture. Estimated based on Statistics Canada (2003) Livestock feed requirement study 1999-2001. 23-501-XIE

Chart 28 shows the areas of pasture and feed-land used by Canadian beef producers[43] (See Appendix 3 table 3 for complete data).



The area in pasture stayed relatively stable at approximately 15,500,000 ha, while seeded pasture increased from 4,140,000 ha in 1989 to 5,694,400 ha in 2005 (STATCAN-COA 2001; 2007). There was also a large increase in the cropland devoted to growing cattle feed (grain and hay) from 7,810,900 ha in 1989 to 9,521,400 ha in 2005.

9.1.3 The world's connections with Canada

9.1.3.1 Agricultural export

Canada is a major international supplier of agricultural products such as grains, oil seed and meat products. Over the research period, there were several changes to Canada's agricultural production processes dedicated to exports: In 1989 the weight of exported agricultural crops included in my study was 28,166,200 Mt; by 2004 it had increased to 50,923,500 Mt (chart 29) an increase by a factor of 1.8[44]. Table 33 presents the average Canadian agricultural export divided to the major agricultural products, each group export as part of production and the

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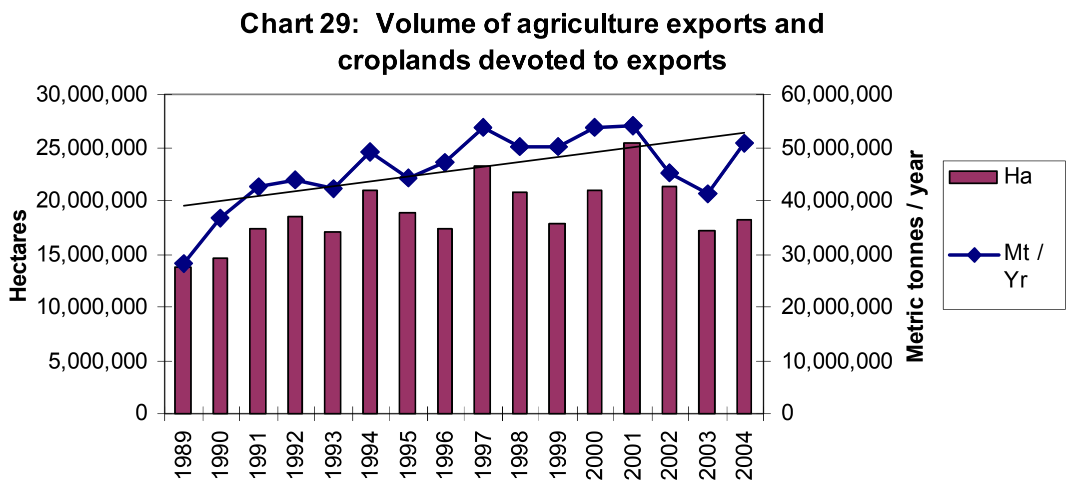
[43] The actual feed land is larger - for the lack of reliable data, figure '5' includes only part of the land appropriated to silage (Barley and fodder corn) and does not include other roughages.
To prevent double counting of crop lands figure '5' does not include the land needed to grow soy and canola meal (which are by products of oil production calculated as part of these crop lands).
The amount of feed per animal for the whole period was calculated based on 1999-2001 data Statistics Canada (2003) Livestock feed requirement study 1999-2001. 23-501-XIE.

[44] These export figures include all the crops covered in the study as well crops embodied in exported beef products.

average annual change in export (For the complete data see appendix 3 table 4). Also evident is an increase in the physical inputs required to grow the different products (chart 29 and table 34). In 1989 the land devoted to export crops was 13,796,400 ha; by 2004 it was 18,253,200 ha. The highest level was recorded in 2001 at 25,368,500 ha. Finally, the proportion between production for local consumption and export changed as well (table 33); in 1989, 29.2% by weight of agricultural crops included in my study were devoted to export, compared to 45.8% in 2004. Again, in 2001 exports represented the highest proportion of total production at 61.4% of the harvest. In twelve of the sixteen years studied, the area of land devoted to export exceeded 50% of overall cropland (chart 30; table 34).



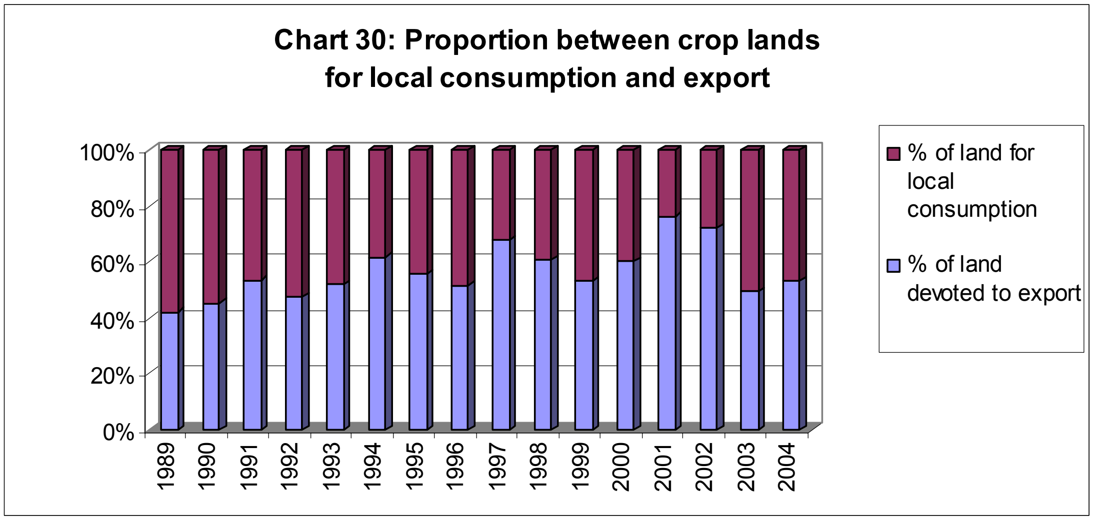


Table 33: Agricultural products devoted to export by weight and as a proportion of production[45]

	Average export	Standard deviation	% of production exported	Average annual change
	Tonnes	Tonnes	%	+/- %
Fruits	109,550	18,860	14.6	+ 4.6
Grains	29,657,700	4,246,560	52.7	+ 4.1
Hay	7,936,800	1,572,000	32.1	+ 5.7
Legumes	1,489,820	819,290	61.1	+ 15.8
Oil seeds	5,164,720	1,606,200	60.4	+ 8.0
Potatoes	1,314,140	637,120	31.3	+ 11.4
Vegetables	232,070	117,340	13.4	+ 24.7
TOTAL	**45,904,800**	**6,926,660**	**45.9**	**+ 4.8**

Table 34: Overall estimated physical inputs involved in Canada's export products

		1989	1992	1995	1998	2001	2004
Land	**Ha**	13,796,400	18,530,300	18,877,300	20,783,700	25,368,500	18,253,200
Water	**1000s M_3**	30,349,900	49,792,300	47,016,400	51,217,800	53,807,500	48,547,400
Fertilizers	**Mt**	1,163,600	1,463,300	1,506,300	1,649,100	1,877,100	1,397,900

Chart 31 presents the distribution of Canadian exports by weight to international destinations for the study period. Chart 32 presents the percentage of land devoted to production of agricultural exports destined for each region in selected years[46] (For the complete data see appendix 3 tables 4 and 5).

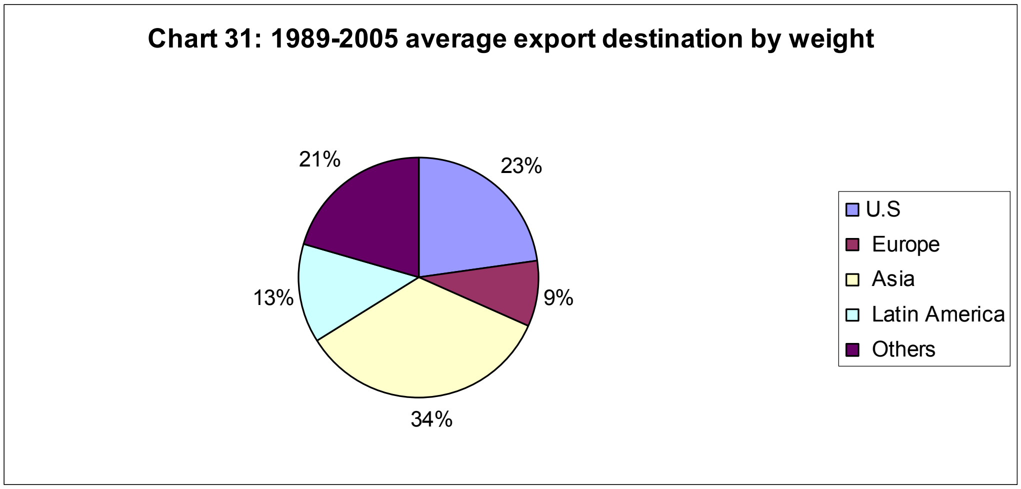


Chart 31: 1989-2005 average export destination by weight

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[45] The figures presented in table 33 were calculated based on data from the following sources: Statistics Canada Grain Trade of Canada, 22-201-XIB; FAOSTAT 2007; UN COMTRADE 2006; CHASS (2007) Canada's trade analyser.

[46] The results presented in charts 31 and 32 were calculated based on data from the following sources: CHASS (2007) Canada's trade analyser; FAOSTAT 2007; and Statistics Canada Grain Trade of Canada, 22-201-XIB

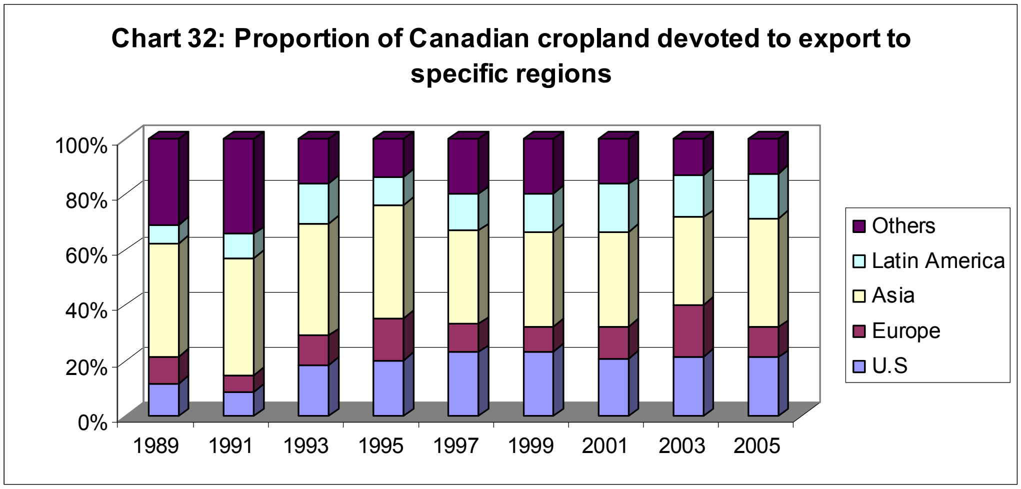
Chart 32: Proportion of Canadian cropland devoted to export to specific regions

9.1.3.2 Beef and livestock export

Another significant change within the research period is an increase in the export of beef and cattle livestock (chart 33). In 1989 Canada exported the equivalent of 872,530 head of beef cows (both as livestock and beef products); in 2005 that export reached the equivalent of 2,241,870 head of cattle. The peak year for the study period was 2002 when the equivalent of 3,425,480 head was exported (chart 33)[47]. The proportion of Canadian cattle slaughtered for export has changed as well from 12.2% in 1990 to 39.4% at 2005. According to Statistics Canada (2003:3) Canada has become the world's third largest beef exporter[48]. On average 14.2% of Canada's overall farmland is devoted to growing beef for export. Chart 34 presents this land input for selected years (For the complete data see appendix 3 tables 6).

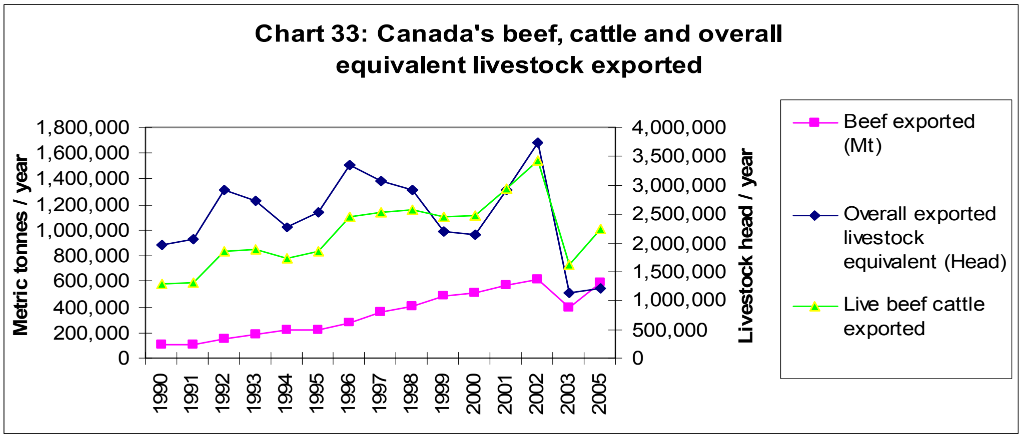
Chart 33: Canada's beef, cattle and overall equivalent livestock exported

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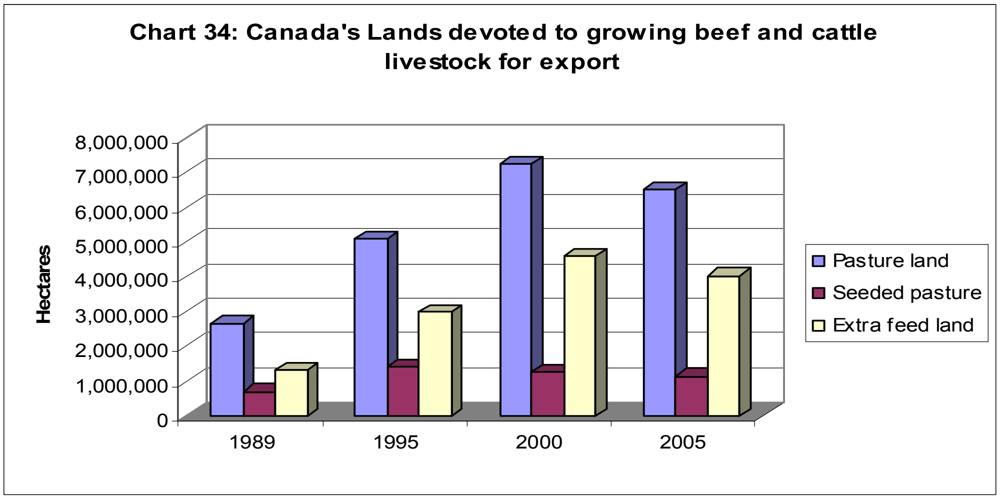
[47] Statistics Canada (2007) Cattle statistics Catalogue no. 23-012-XIE, Vol. 6, No. 1

[48] The drop of livestock export in 2003-2004 was a result of mad cow dieses and the closure of the U.S border. Statistics Canada (2003) Mad cow disease and beef trade. 11-621-MIE2003005



9.2 Agricultural production and ecological changes in the Canadian prairies

> In the old world of Europe and Asia, no one can quite remember what 'natural' looked like, because the land has been successively shaped and reshaped to meet human needs for hundreds or thousand of years. But in the new world of the prairies – right up to the moment when the settlement boom began – humans had lived off natural productivity of this vast, sun swept expanse of grass" (Savage 2004:16).

The Canadian prairies are the northern portion of the vast North American Great Plains eco-zone. They are located in the southern half of Alberta, Manitoba and Saskatchewan provinces of western Canada. Altogether the prairie region covers 113 million Ha or 11.3% of Canada's land area, and is composed mostly of semiarid grasslands and sub humid aspen parkland (Natural Resources Canada, 2004). The region's climate is characterized by long, cold winters and hot, dry summers; the annual precipitation ranges from 300mm – 600mm, and falls mostly in spring (IISD 1997). A unique combination of physical, climatic and biological factors shaped the region. A set of geological and geomorphological processes shaped the landscape and hydrology - the glacial deposits that repeatedly covered the region in the past left behind outwash plains of sand and silt, which generated, over thousands of years, rich and fertile soil, often several meters thick (Acton 1995). The soil's physical characteristics and moisture conditions determined the flora and fauna communities; animals were influenced by the available vegetation, while soil decomposers and the physical characteristics of soil were influenced by the plant and animal populations (IISD 1994; Savage 2004).

While in the past, climate, fire and grazing were dominant factors influencing natural prairie environments; the cumulative impacts of human activities over the last century have played the largest role in reshaping the region. Local and global demographic trends, increasing local and international consumer demands, the economics of farming and ranching combined with agricultural policy and industrial development— all have been driving forces in the impacts of human activity throughout the prairies.

9.2.1 Prairie agricultural production

> “The agricultural region of Western Canada is a landscape full of opportunities. With an expanding world population and economy, global demand for agricultural products will continue to increase. Much of Canada’s primary and value-added production needed to meet future demands for agriculture and agri-food products is expected to come from the Prairies. Livestock production is projected to increase significantly, while crop production will diversify and intensify. More processing of agricultural products will occur in the Prairie region as it capitalizes on emerging opportunities in an expanding global market” (AAFC-PFRA 2000:1)

The combination of rich soils, vast lands and favorable agro-climatic conditions has made the prairies Canada’s major agricultural region, representing approximately 70% of the lands suitable for agricultural cultivation – 32,161,600 Ha, comprises 81.1% of Canadian farmland (Canada Land Inventory 1978; STATCAN-COA 2007). It produces the vast majority of grains, oil seed, legumes and livestock (Table 6).

It was not more than a century ago that the agricultural potential of the region was identified. Previous to that time, most of the region was relatively untouched by humans; those who did live there, lived on the region’s natural capacity and generally occupied only the river bank areas (Acton 1995; Savage 2004).

Chart 35 presents the prairie land occupied by farming (crops, fallow and pasture) throughout most of the last century[49]. While within the study period the overall size of the prairie farmland has been more or less constant (at around 55,000,000 Ha), the area of cropland has been constantly increasing (Table 36). A large proportion of production is for export (Table 35), which makes Canada’s prairie region a major breadbasket for consumers throughout the world.

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[49] Statistics Canada (2002) Historical Overview of Canadian Agriculture 93-358-XPB; Statistics Canada 2006 Census of Agriculture.

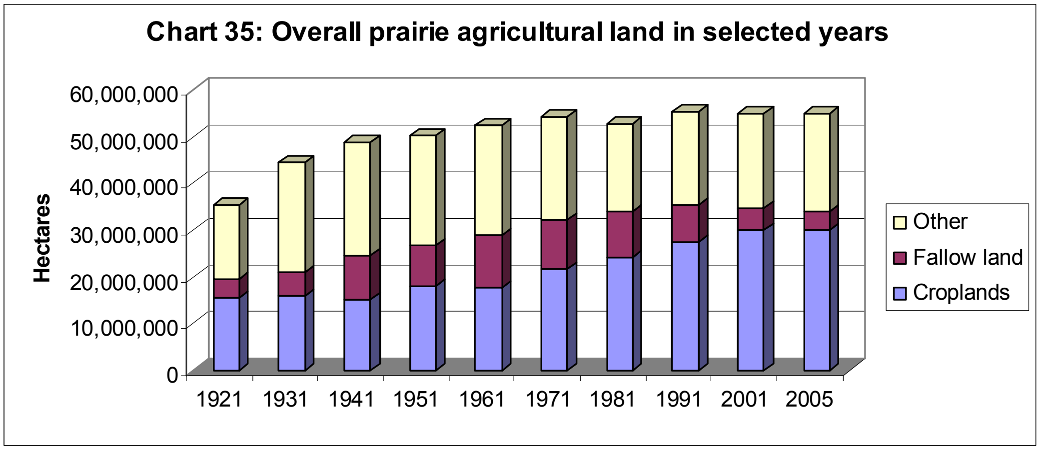

Table 35: Prairie agricultural production as a proportion of overall Canadian production

		Canada's yearly average production (1989-2005)	Prairies yearly average production (1989-2005)	% of overall production	% of production exported
Wheat	**Mt/Yr**	25,796,800	24,247,150	93.8%	71.1 %
Barley	**Mt/Yr**	12,360,600	11,225,470	90.5%	60.0 %
Oats	**Mt/Yr**	3,288,800	2,840,800	85.8%	57.8 %
Rye	**Mt/Yr**	364,890	311,560	83.2%	45.5 %
Flaxseed	**Mt/Yr**	785,250	785,250	100%	80.7 %
Rapeseed(Canola)	**Mt/Yr**	6,033,100	5,938,200	98.4%	70.0 %
Peas	**Mt/Yr**	1,625,850	1,620,700	99.7%	65.3 %
Hay	**Mt/Yr**	25,898,000	12,639,500	48.6%	32.1 %
Beef cattle	**Head**	11,823,500	9,511,000	80.4 %	38.0 %

Table 36 presents the major physical inputs involve in agricultural production in that region. These figures representing a significant portion of the overall Canadian agricultural inputs: 81% of the land (STATCAN-COA 2007); 75% of the agriculture water withdrawal (Environment Canada 2002); 71% of commercial fertilizers (Statistics Canada 2002); 47% of pesticides[50] (Environment Canada 2005) and 62% of the overall agricultural energy inputs (Natural resources Canada 2007).

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[50] For the lack of accurate data this figure does not include Saskatchewan, which is probably a major user of pesticides.

Table 36: Physical inputs involved in agricultural production in the Canadian prairies

			1991	**1996**	**2001**	**2005**
Farmland[51]	Ha		55,401,500	55,330,400	54,934,900	54,816,600
Cropland[52]	Ha		27,506,250	28,638,950	29,871,160	30,054,500
Water[53]		1000s M_3	69,520,300	76,787,200	55,386,800	76,447,800
Irrigated land [54]	Ha		N/A	636,170	595,880	632,290
Fertilizer[55]	Mt	Nitrogen	844,330	1,260,960	1,262,140	1,237,970
	Mt	Phosphate	377,490	498,190	479,240	492,250
	Mt	Potash	68,630	90,810	120,410	151,220
Fertilized land[56]	Ha		N/A	20,877,440	20,139,800	21,308,300
Pesticide[57]	Ha	Herbicides	N/A	20,322,670	22,516,950	21,417,400
	Ha	Insecticides	N/A	2,366,820	1,655,710	1,675,200
	Ha	Fungicides	N/A	1,465,550	2,197,130	2,410,200
Energy [58]	TJ[59]		111,400	129,800	116,300	110,100
Production [60]	Mt		**66,079,900**	**70,663,500**	**52,926,100**	**74,672,200**

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[51] Canada Census of Agriculture 2006 - STATCAN-COA (2007)

[52] Canada Census of Agriculture 2006 - STATCAN-COA (2007)

[53] Calculated based on Canadian national water inputs. Does not include water use for: hay, sunflower, lentils, vegetables and fruits. Data source: Chapagain, A.K. and Hoekstra, A.Y. (2004) '*Water footprints of nations*' @ www.waterfootprint.org.

[54] Statistics Canada - Census of Agriculture 2006 table 4.12-1

[55] Statistics Canada (2002) Canadian fertilizer consumption, shipments and trade. pp.17;
Canadian Fertilizers Institute (2007) Canadian fertilizers information system.

[56] Canada Census of Agriculture 2006 - STATCAN-COA (2007) tables 4.8-3,4

[57] Land (Ha) treated with pesticide - Statistics Canada - Census of Agriculture 2006; herbicides table 4.8-1; Insecticides table 4.8-2; Fungicides table 4.8-3

[58] Natural resources Canada (2007) Secondary Energy Use and GHG Emissions by End-Use and Energy Source – Tables 8, 9, 10 @ http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_agr_mb.cfm

[59] Tera joule per year; 2005 figure based on 2004 data.

[60] Include the total weight of: grain, oilseed, legumes, hay, and sugar beet. Does not include vegetables and fruits.
Source: CANSIM tables V169 series.

9.2.2 Ecological changes

In the following paragraphs I highlight connections between agricultural activities, the use of physical inputs, and ecological changes (habitat change, soil degradation and implications for loss of biodiversity). Some ecological changes occurred as a result of past agricultural expansion in the prairie region; other changes are still occurring today. These changes not only diminish the function of the natural ecosystems in the region but now jeopardize its future ability to support consumer demands for agricultural products (Senate 1984; IISD 1994; AAFC-PFRA 2000). Within the last century or so agricultural activities have played a major role in changing the natural ecosystem of the prairies (IISD 1994; AAFC-PFRA 2000; Savage 2004).

9.2.2.1 Habitat change

Up to the late 19th century the whole prairie region was covered by a mixture of perennial grasses, forbs and shrubs (Environment Canada 2007). The species and types of cover were determined by the soil type and moisture availability (Savage 2004). The grassland extended southward from the boreal forest into a transition zone of Aspen grove to mixed grass prairie and short –grass prairie, with the northern tip of tall prairie grassland extending into south eastern Manitoba (AAFC-PFRA 2000). Those prairie grasslands are significant for sustaining the natural prairie ecosystem. Several studies have emphasized the role and diversity of these grasslands (Coupland 1950; Savage 2004).

> “Native grasses are the heart and soul of the prairie, the living link between the physical resources […] and almost every other aspect of the ecosystem” (Savage 2004:64).

The different kinds of grass which once covered large areas of prairie lands are adapted to the extreme conditions of drought, frost and heat which characterize that region (Coupland 1950). The grasses contributed to sustaining the prairie soil and a large and diverse group of organisms. Samson and Knopf (1994) estimated the size of the land historically covered by grass at approximately 15,200,000 Ha (Alberta – 8,700,000 Ha; Saskatchewan – 5,900,000 Ha; Manitoba – 600,000 Ha). Coupland (1950:285) studied the mixed grass regions of Alberta and Saskatchewan; he identified dozens species of grass and shrubs. A study on biodiversity in Saskatchewan (SBIC 1999) estimates an overall 4,500 plant species in that province.

The prairie region supports a diverse wildlife population as well[61] including large populations of grazing animals (e.g., bison, elk, pronghorn antelope, jack rabbit, ground squirrel, gophers), predators (e.g., plains wolf, plains grizzly bear, black-footed ferret, swift fox, long-tailed weasel, badger, and coyote), reptiles (e.g., western hognose snake, smooth green snake and prairie rattlesnake) and birds (e.g., long-billed curlew, Swainson's hawk, ferruginous hawk, burrowing owl, black-billed magpie, brown thrasher, Sprague's pipit, Baird's sparrow, chestnut-collared longspur, lark bunting, western meadowlark, and brown-headed cowbird). A study by the North American Commission for Environmental Cooperation (CEC 2003) identified 32 species of birds that are 'highly dependent' on the prairies grassland of Canada and the U.S.

In the past large areas of the prairies were covered by wetlands widely recognized for their biodiversity, as nutrient sinks, and as breeding and nursery habitat for waterfowl and fish. It is estimated that the Canadian Prairie wetlands serve more than half of North America's waterfowl (Savage 2004). These wetlands are also home to numerous amphibian species, (e.g., northern leopard frog, boreal chorus frog, Great Plains toad, Canadian toad, and plains).

While in 1881 about 113,000 Ha of the Canadian prairies were cultivated, by 1900 another 2,000,000 Ha were cleared and plowed (IISD 1994:21). The rapid pace of agricultural development continued and by 1921 about 35,600,000 Ha of the prairie provinces' lands had become farmland, of which 13,000,000 Ha were croplands (chart 12). Since then prairie land devoted to farming has grown to over 54,800,000 Ha, 30,054,500 Ha of which are croplands (STATCAN-COA 2007; chart 12).

According to Environment Canada (2007) more than 99% of tall grass prairie, 80% of fescue prairie, and 67% of mixed-grass prairie habitat has been lost to agricultural development. In Alberta 61% has been removed (3,400,000 Ha of mixed grass remains); in Saskatchewan almost 86% (840,000 Ha of short grass remain); and in Manitoba 99.9% has been lost (300 Ha of tall grass remain)[62]. The change from the natural diverse grassland cover to mainly monoculture agricultural land cover put pressure on wildlife and the biodiversity in the prairies. Several studies show the difference between the scope of wildlife activity and its diversity in natural versus agricultural systems. For example, a study in Saskatchewan (as cited in Savage 2004:238) found that a relatively small 11 Ha patch of natural grassland provided habitat to twice as many species of butterflies as did surrounding cropland. In Alberta for example, the list of species

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[61] Data sources: SBIC (1999); PCAP (2003); Savage (2004); PCF (2006); Canadian Biodiversity web site @ http://canadianbiodiversity.mcgill.ca/.

[62] Samson and Knopf (1994); PCF (2006); PCAP (2003)

under serious risk of extinction includes: 8 species of mammals; 3 reptiles; 3 fish; 5 amphibians and 13 species of birds. The North American Commission for Environmental Cooperation (CEC 2003) found that 60% of prairie endemic birds have been in decline within the last several decades. Still, it is believed that the list of species under threat is far from complete and that most species at risk of extinction have not been documented yet.

Prior to intensive cultivation, the natural prairie land cover of native grasses was extensive and contiguous. Expansion of farmland decreased the overall size of the natural prairie habitat, and the remaining natural habitat has been fragmented into small islands surrounded by non-native vegetation. This habitat fragmentation is a major threat to biological diversity; it impedes the movement of wildlife in their search for food and habitat (PCF 2006). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2004) has estimated that approximately half of the listed species at risk are in farmland areas. Javorek et al. (2005:160) have studied the change of wildlife biodiversity on agricultural land. They make a correlation between declining wildlife on agricultural land and the expansion and intensification of Canadian agricultural activities in recent decades. The study included 337, 311, and 290 wildlife species known to use agricultural land in Alberta, Manitoba and Saskatchewan respectively. Their study estimated the capacity of farmland to sustain wildlife habitat in 1991 and 2001[63]. In Alberta they found that habitat capacity had decreased in 88% of the farmland, while it increased in about 2%; in Manitoba 64% of farmland had a decreased habitat capacity while 3% increased; and in Saskatchewan 92% saw a decrease while approximately 2% had an increase.

Another consequence of agricultural activities in the prairie region is the loss of wetland habitats. Approximately 70% of historic wetlands of the Canadian prairies have been drained, mostly to be converted into farmland (Seburn and Seburn 2000). Bethke and Nudds (as cited from Sinclair et al. 1995:581) have estimated that since the 1950s Manitoba has lost approximately 190,000 ha of wetland, Alberta has lost 400,000 ha and Saskatchewan roughly 50% of provincial wetlands (SBIC 1999).

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[63] "The Wildlife Habitat on Farmland Indicator provides insight into the trends in wildlife habitat available on agricultural land in Canada. The indicator, associate land area, land use and wildlife use (habitat capacity)" (As cited from Javorek et al. 2005:158)

9.2.2.2 Soil degradation:

The quantity and quality of the prairie soils are key to the region's ecological sustainability as well as the sustainability of agricultural production (AAFC-PFRA 2000:20; AAFC 2005). A large portion of the prairie soils possess physical, chemical and biological attributes suitable for agricultural crop production - deep and well drained soils; good structure; good water holding capacity; high levels of biological content; and adequate quantities of available nutrients (IISD 1994:68; Acton 1995:14).

A unique aspect of the prairie soils is their biodiversity content - the scale of life under the surface. Overall it has been estimated that between 60 and 90% of the prairies' biodiversity is in the soil (Savage 2004:92). For example, the upper 30cm of one square meter of prairie soil can support between 5,000 and 15,000 springtails; 60,000 mites (divided into dozens of species); more than 3,000,000 nematodes; as well as many other algae, fungi, bacteria, and protozoans (Savage 2004:94). For thousands of years, symbiotic relations between prairie flora and underground organisms made the soil rich with organic matter and nutrients. The combination of rich diversity of life in the soil and the diversity of surface vegetation is a major ingredient of the fertile agricultural soil of today's prairies.

Since the beginning of agricultural activities in the prairies, however, the quality and quantity of the soils have declined. Soil degradation in the form of soil erosion, loss of organic matter and land salinization contributes to biodiversity loss, decline of ecosystems structure and function, and decreasing agricultural yields (Dumanski and Brklacich 1992; AAFC 2005). Because of its severity and potential negative consequences for future agriculture production, the issue of soil degradation has received relatively broad attention in recent years (e.g., Senate 1984; IISD 1994; Acton and Gregorich 1995; AAFC-PFRA 2000; AAFC 2005). The discussion here focuses on two major aspects of soil degradation: loss of soil organic matter and soil erosion.

Loss of soil organic matter: Soil organic matter includes plant and animal remains in various stages of decomposition, cells and tissues of soil organisms, and substances produced by soil microbes (IISD 1994; Gregorich et al. 1995). The amount and composition of the organic matter is affected by climate, vegetation, topography, and parent materials. Prairie soils, formed in grassland ecosystems contain large quantities of organic matter (Senate 1984; Savage 2004). Gregorich et al. (1995:42) suggest that about 10% of the upper 30cm of the soil weight is organic matter, of which 70% is stable organic matter (humus) and 30% is active. Out of that, 40% are living organisms (50% fungi; 30% bacteria; 10% yeast; 10% fauna).

The function and sustainability of the prairie ecosystem is dependent on that organic soil content; it feeds and provides the energy for a large number of underground organisms (Savage 2004). The organic matter content of the soil is also essential to agricultural activities. Following IISD (1994:73), AAFC-PFRA (2000) and AAFC (2005:108) the importance of soil organic matter for agriculture is: (I) increase soil granulation, which helps to create a desirable soil structure for agricultural crops; (II) reduce the plasticity and cohesion of wet soils which helps to increase the water holding capacity of the soil (a critical factor in the prairie region); (III) act as absorber and exchanger of carbon and plant nutrients.

When first cultivated, prairie soils are organically rich and fertile (Acton 1995:15). That natural fertility, particularly the high organic matter content, enables farmers to produce high yields of agricultural products with minimal use of artificial fertilizers (Senate 1984:45). However, over time, agricultural activities reduce the organic content of the soil and contribute to its degradation. All studies indicate a significant decline in soil organic content in the prairies since the beginning of agricultural cultivation. Studies in the 1970s and 1980s (as cited from Gregorich et al. 1995:45) suggested losses of up to 70%. Wang et al. (1995:39) found a 50% decline of the organic matter content over 80 years of cultivation on a farm in Alberta, and Smith et al. (1997; as cited from AAFC-PFRA 2000:49) suggest a decline in the range of 14%-40%. Gregorich et al. (1995:41) estimated the decline at 15%-30%, and IISD (1994:74) estimated that between 36%-49% of the soil organic matter of the prairies was lost solely due to the effect of cultivation during that time.

Unlike other ecosystems where a large portion of the carbon content is found above ground in plants and residues (e.g. forests), in prairie ecosystems most of the carbon is in the soil (Gregorich et al.1995:43; Savage 2004). That carbon is essential for natural vegetation as well as for agricultural crops. The removal of organic matter reduces that carbon content which affects the function of other organisms in the soil and reduces the carbon available for agricultural crops. Large amounts of nitrogen, phosphorus and sulphur are held in organic forms; the removal of the organic matter removes a large portion of the nutrient content as well. According to the 1984 report to the Standing Senate Committee on Agriculture (Senate 1984:46), while some natural prairie soils hold up to 140 kg of nitrogen per hectare, the same soil after years of agriculture cultivation holds as low as 10 kg per hectare. The consequence of that decline in nitrogen has been an increase in use of external (mostly synthetic) fertilizers. In recent decades a significant increase in fertilizer use in the prairies has been documented, from an overall of 307,000 Mt of commercial fertilizers in 1972 to 1,881,440 in 2005[64].

Land use and farming practices have significant effects on the content and composition of the organic matter in prairie soils. In recent years, increasing awareness of the potentially negative consequences of continued loss of organic matter have led to more conservation practices in prairie agriculture (e.g., minimizing summer fallow land; increasing crop rotation; reducing tillage). A recent study by Agriculture Canada (AAFC 2005:110) estimates that in 2001 58% of prairie croplands saw an increase in organic matter content (compared to only 26% in 1991). At the same time organic matter content decreased in 29% of the lands.

Soil erosion: The erosion of soil is a natural process of detachment and transport of soil material by running water, wind or gravitational forces (IISD 1994:74). As long as the land was covered by grass and shrubs and the soil organic matter content levels were high, the ability of wind and water to erode the soil was minimal. The problem of soil erosion began when agricultural activities stripped large portions of the region and exposed the bare soil to wind and water.

Wind erosion occurs from strong winds during dry conditions on lands with little to no surface cover (AAFC-PFRA 2000:22). Cropland, mostly summer fallow and crops prior to seedling establishment, exposes soil to wind. A combination of drought and bare soil cover accelerates soil erosion. Several studies estimated the size of the land damaged by wind erosion in the prairies: Wall et al. (1995:67) estimate that at the mid 1990s 59% of cultivated prairie lands were under moderate to high risk of wind erosion while 6% are under severe risk conditions. The IISD (1994:75) estimated that 6,310,000 Ha of cultivated prairie lands has been damaged by wind erosion. A recent study (AAFC 2005:98) has documented a reduction of the amount of soils at risk of wind erosion by 40% since the 1980s. It estimated that 6% are under moderate to high risk while only 3% are under severe risk conditions.

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[64] Data from : AAFC (2004) Canadian fertilizer consumption, shipments and trade 2001/2002; Canadian Fertilizers institute (2007) Canadian Fertilizers information system.

Water erosion happens on soils with varying degrees of slope when rainfall amounts exceed the water infiltration rate. Several studies have estimated the size of the land damaged by water erosion: The IISD (1994:75) estimated that 4,640,000 Ha of cultivated prairie lands were damaged by water erosion. Wall et al. (1995:68) estimated that 45%, 23%, and 24% of cultivated lands in Alberta, Saskatchewan and Manitoba respectively were under high risk of water erosion at the beginning of the 1990s'. Again the AAFC (2005:92) study provides more optimistic figures at 6%, 6%, and 2% (Alberta, Saskatchewan and Manitoba respectively) of cultivated lands under high risk of water erosion in 2001.

As most eroded soil is topsoil, soil erosion in the prairies results in the removal of essential organic matter. Because one of the functions of organic matter is to improve soil structure and to improve its water holding capacity, the removal of organic matter by erosion increases the vulnerability of the soils to more erosion.

9.3 Summary

Although Canada is a vast country, only 5% of its terrestrial area can be used for agriculture. Nevertheless, both Canadians and consumers in other parts of the world depend on that area to provide a portion of their food. Canada, particularly its prairie region, is a major bread-basket for world consumers. An increasing quantity of agricultural products is exported each year.

On average within the research period 46% of Canada's agricultural crop production and 38% of beef production were devoted to consumers in other parts of the world. Most of that production for export is taking place in the prairie region of the country where even greater portions of production are for export. In effect Canada is now exporting between 40 and 50 % of its food carrying capacity.

Overall in terms of weight close to 70 % of Canada's agricultural crops are grown in the prairie region and some major products represent even higher proportions; 94% of wheat; 90% of barley; 100% of canola seeds and peas, and 80% of cattle livestock. A significant portion of all of these major agricultural products is exported. As documented here agricultural production in the prairie region involved 81% of Canada's farmland; 75% of the agriculture water withdrawal; 71% of commercial fertilizers; more than 50% of pesticides, and 62% of the overall agricultural energy inputs. That agriculture production has, in a relatively short period, dramatically affected the structure and function of the original prairie ecosystems: most of the natural land cover replaced by monoculture agriculture and the remaining natural areas are broken into small islands.

The intensive agricultural activity also led to the loss of biodiversity and to a significant process of soil degradation. These trends all risk the long-term sustainability of the agricultural sector itself and have potentially serious implications for future ability of the region to continue supporting both domestic and international consumers.

Particularly because of the ecological changes highlighted in this chapter, physical inputs to agriculture and production have increased over the research period to maintain productivity and continue to do so. In recent years some improved agricultural practices have reduced the pace of some forms negative change (e.g., soil degradation) other aspects continue to deteriorate (e.g., soil and water contamination; biodiversity loss). In light of the interregional approach discussed here, that intensive agricultural activity can also be seen as a result of increasing demand by consumers all over the world for Canadian agricultural production. As more people are becoming dependent on that region productivity, the sustainability of the Canadian prairies should be of interest not only to prairie farmers and Canadians but also to dependent consumers in other countries.

Chapter X - Summary and discussion

This dissertation takes a first step toward developing and applying an interregional approach to sustainability planning, empirically testing some aspects of such an approach and identifying some critical implications for both local and global sustainability. The premise is that globalization is increasing interregional trade and interdependence and that insufficient attention has been paid to the global ecological and geopolitical implications of these trends at a time of increasing global change and resource shortages. The overall research question is: How can inter-regional ecology and disaggregated eco-footprint analysis be used to illustrate the extent and intensity of inter-regional connectivity and help provide the basis for assessing its implications for local and international sustainability?

I make the case that in an increasingly interconnected, globalizing world, conventional, production and local pollution-oriented approaches to sustainability are insufficient. Our focus should be widened to include material consumption and we need to broaden the spatial scale of analysis to make linkages to negative impacts on the structure and function of supporting eco-systems. This would help account for some of the 'externalities' of globalization and international trade, provide a form of 'negative feedback' about our actions, quantify our increasing interdependence and identify some of the hidden ecological consequences. This thesis advances a conceptual framework and quantitative basis for the international community to develop and implement more sophisticated, explicitly interregional policies and institutions for sustainability, that also have implications for local sustainability planning.

I developed a method that involves disaggregating the 'ecological footprint' of any study region and assigning specific components to other supporting regions around the world. I also estimate some of the physical inputs required to maintain that support, specify critical elements of various traded commodities' life cycles, and link the latter to some local ecological impacts.

This concluding chapter summarizes and analyzes my findings and their implications including suggestions for further research.

10.1 Summary of the research findings:

My overall goal was to reveal the implications for sustainability of the increasing material entanglement among nations that result from accelerating globalization. Substantive research objectives were to describe and quantify the interregional material linkages between selected countries; to document the extent that trade flows are increasing the material interdependence of various nations, and to identify linkages between material consumption in one country and the loss of ecological integrity in others. My methodological objective was to create a conceptual tool to trace material flows and characterize the external ecological footprint of importing regions. Finally, my study illustrates the theoretical relevance of ecological thinking on an interregional scale to planning for sustainability at both local/regional and global scales.

Energy and material production and consumption drive many unsustainable trends. While significant, the relationships and impacts documented here are just a few of the multiple linkages among consumption, production and ecological change that are intensifying around the world. Major challenges to the analysis include enormous data requirements, poor data availability, inconsistent data collection and accounting among nations and agencies, and practical limits of the time and other personal resources available for a study of potentially enormous scope. I employed case studies to analyze three dimensions of interregional relationships: import, export, and specific regional and product connections. Each dimension, while related to the others, contributes a separate piece to the puzzle of interregional human ecological relationships. Together they provide a relatively comprehensive perspective on ecological connections among regions and suggest numerous implications for global sustainability.

A major contribution of this dissertation is the development of a method to trace material flows and to characterize the external ecological footprint of importing regions on exporting countries. For example, the average U.S. external material eco-footprint attributable to the import flows examined is 146,729,000 ha, an area of land equivalent to the size of Germany, Italy, Spain, Switzerland, and the United Kingdom combined. Much of that land is forest land; the remainder is pasture and crop land. On average between 1995 and 2005, the area of land devoted to producing the U.S. imports of forest products was 81,204,000 ha; for meat and livestock 50,720,000 ha; and for agriculture crops 14,805,000 ha.

The data also show that this area of 'appropriated biocapacity' is increasing as U.S. imports increase. During the period studied the weight of imported agricultural products increased by 51%, meat by 77% and forest products by 45%. This resulted in a 24% increase in the size of the U.S. external material ecological footprint from 134,351,000 ha in 1995 to 165,913,000 ha in 2005, an average annual increase of 3,156,000 ha.

Furthermore, not only that the U.S. external ecological footprint has increased during the research period, the research findings also reveal an increasing reliance of the U.S. on external sources out of overall consumption. Imported wood as a fraction of total consumption increased from 23% in 1995 to 30% in 2005 (an average of 26%); meat imports as a fraction of consumption increased from 9% in 1995 to 16% in 2005 (an average of 12%). The overall share of the agricultural crops imported stayed stable at around 12% of consumption over the period studied[65]. However, a closer examination of the data shows that the import share of consumption of some agricultural crops is well above the average over the period studied, for example: fruits (33%); oil crops (20%); stimulants (24%); and agricultural fibers (44%). Moreover the share of some has increase significantly during the research period, for example: Fruits increased from 28% in 1995 to 41% of consumption in 2005; Legumes from 5% in 1995 to 12% in 2005, stimulants from 23% in 1995 to 30% in 2005, and agricultural fibers from 43% in 1995 to 49% in 2005. Furthermore, some commodities are entirely imported, that include such commodities as: coffee, tea, cocoa, bananas, mangoes, olives, palm oil, and natural rubber.

In addition to identifying a pattern of increasing U.S. reliance on external sources, the analysis also reveals some of the pressures imposed by the U.S. and other consuming nations on supporting ecosystems in Costa Rica and Canada. It quantifies the areas of productive ecosystems 'exported' in selected trade goods from Costa Rica and Canada, documents other physical inputs required for that production and highlights some of the relationships between production for export and specific ecological changes such as the loss of habitat, soil degradation, water contamination, and biodiversity loss in the exporting nations.

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[65] this was up from only 8% during the 1980s

In the case of Costa Rica, I found that on average 53% of crop production by weight and 25% of beef production were exported. The export share of total production by weight increased during the research period from 44% in 1989 to 74% in 2004. Furthermore, export production 'appropriated' an average of 30% of that country's agricultural land (46% of cropland and 25% of pasturelands), increasing from 36% in 1989 to 62% in 2004. On average about 47% of the Costa Rican agricultural export by weight was exported to the U.S. followed by 25% to the European Union countries. During the research period 8 agricultural commodities (bananas, cassava, coffee, melons, oil palm, oranges, pineapples and sugar) comprised 93% of the overall Costa Rican agricultural production weight. Fifty seven percent of production of these commodities was exported representing 48% of the country's cropland, 57% of the water inputs, 82% of artificial fertilizers, and around 40% of pesticides.

In Canada, on average during the research period, 45% of crop production by weight and 38% of beef production was exported. The export share of total production by weight increased during the research period from 30% in 1989 to 47% in 2004. Furthermore, export production 'appropriated' an average of 56% of that country's cropland and 38% of pastureland; cropland has increased from 42% in 1989 to 72% in 2002 (and down to 53% in 2004) and pastureland from 17% in 1989 to 42% in 2004. On average during the research period 34% of Canadian agricultural crops export by weight was exported to Asia followed by 23% to the U.S. and 21% to the European Union countries.

After quantifying the physical inputs involves in production for export; estimating the amount of inputs required to support consumers in several importing countries, I documented some of the linkages between agricultural activities significantly for export, the use of the documented physical inputs, and processes of ecological degradation in the studied countries. My major focus was on the production of bananas, coffee and beef in Costa Rica, and on agricultural production in the Canadian prairies. Still, documenting all linkages between production activities and processes of ecological degradation are beyond the scope of this dissertation or any available data. Linkages considered include:

(1) Loss of habitat – In Costa Rica more than 70% of the natural forest cover has been converted mostly into agricultural land. The bananas, coffee and beef studied here are responsible for around seventy percent (approximately 2,500,000 Ha) of that deforestation. In Canada, 81% of farmlands (85% of cropland and 80% of pasture land) and 61% of overall agricultural production weight takes place in the Canadian Prairies. Agricultural production in the prairie region significantly for export (On average within the research period 62% of the production weight in the Prairie region was exported involved 60% of the land) has, in a relatively short period, dramatically affected the structure and function of the original Canada's prairie ecosystems: more than 90% of grassland and 70% of the wetlands have been replaced by monoculture agriculture and the remaining natural areas are broken into small islands.

(2) Degradation of soil - Much of the land in both Costa Rica and Canada has been significantly degraded by the loss of natural nutrient and organic endowment of the soils, and the subsequent use of artificial fertilizers to maintain nutrient levels. Both cases also showed high levels of soil erosion as a consequence of exposing the land from its natural cover. For example, 40-57% of Costa Rica's soils have been significantly eroded and 36-50% of the organic matter and natural nutrients content of Canada's prairie soils have been dissipated by agriculture activities. In both cases more than half of the damage can be attributed to soil disturbance in the service of export markets.

(3) Water contamination – Increasing amounts of artificial chemicals have resulted in high levels of nutrients and pesticide residues in water bodies in both countries. In Costa Rica export products use approximately 80% of fertilizers and more than 40% of pesticides, most used by the specific products documented here. Agricultural activities in the Canadian Prairies account for 71% of commercial fertilizers used in Canada and more than 47% of pesticides.

(4) Biodiversity loss – Agriculture has significantly reduced the biodiversity of both crop and grazing lands and nearby natural areas, such as coral reefs in Costa Rica and wetlands in Canada. In Costa Rica the number of species under threat of extinction is in the range of 13 – 28 mammals, 18 - 102 birds, 60 - 83 amphibians, 8 - 36 reptiles, 13 fish and 527 plants. Most of Costa Rica's species are insects (estimated at more than 300,000 species); more than 75% of these are forest species. Therefore the disappearance of forest and specific plant species within forests reduces the number of insects as well. In Canada for example during the last three decades grassland mammal populations have declined by 43% and endemic prairie bird numbers have declined by 60%.

10.2 Analyzing research implications

A major implication of this dissertation is that, in a globalizing increasingly interconnected world, sustainability planning requires an interregional approach:

> The sustainability of human society in any given locale/region is dependent on the productivity and sustainability of supporting regions, wherever on earth the latter may be located. Thus, irresponsible consumption anywhere can jeopardize the sustainability of supporting regions and ultimately of the consuming region as well.

Approaching sustainability from this perspective forces recognition that: 1) virtually every significant human population or country lives, in part, on energy/material flows to and from distant points all over the world; 2) continuous growth in such relationships has the potential to create unseen (by consumers) unsustainable burdens on productive ecosystems in distant locales; 3) ecological degradation in one region has the potential to jeopardize the sustainability of other regions; 4) consumers in importing regions, particularly regions with irreversible ecological deficits, therefore have an interest in ensuring that their supportive ecosystems in other regions are managed sustainably.

In the following paragraphs I discuss some implications of the theoretical approach and empirical findings presented here.

1) Virtually every significant human population or country lives, in part, on energy/material flows to and from distant points all over the world: Human populations everywhere depend on both local and global ecosystems goods and services (e.g., clean air and water, food and materials). In recent decades we have witnessed a great increase in the spatial separation between human populations and the sources of the vital natural resources they consume. For most of human history, people supported themselves mainly on resources and assimilative capacities provided by local ecosystems. With increasing global economic integration this dependence has been extended to sources and sinks in distant parts of the world. Globalization and trade enable people to free themselves from local ecological constraints by importing ecological goods and services; in effect, globalization represents the shuffling of biocapacity from regions with surpluses to other regions some of which have by now greatly exceeded their domestic carrying capacities. This is problematic for several reasons: First, the spatial separation of material production (resource exploitation) from consumption eliminates the negative feedback that normally occurs when people dependent on local ecosystems degrade those ecosystems. Instead, “contemporary consumers remain blissfully unaware of any negative effects of their consumption on supportive ecosystems located half a planet away” (Rees 2006). Second, while globalization and trade allow many regions to develop, it also increases their vulnerability to the ecological degradation of supporting regions and to geopolitical instability anywhere that might jeopardize vital trade linkages. In short, excessive trade dependence might jeopardize the long term sustainability of dependent populations. The cases studied here show an increasing reliance on external sources of supply, including land and physical inputs applied in distant regions.

I documented the increasing flow of most renewable resources into the U.S., quantified the increasing U.S. external ecological footprint, analyzed and emphasized the U.S.’s increasing dependence on external sources. However, the U.S. is also increasingly reliant on the import of strategic non renewable resources such as minerals, petroleum, and a wide variety of processed commodities and on global waste sinks to assimilate many of its wastes such as carbon dioxide and agricultural runoff; thus, its actual import/export dependence is vastly greater than documented here. Obviously the U.S. is just one example, one country that increasing its interregional dependence on others. The interregional approach developed here has implications for other countries as well. Huge countries as China, India and the EU countries are steadily becoming more dependent on external stocks of ‘natural capital, many of which are already over-stressed (e.g., fisheries, tropical forests) or being depleted. While some countries’ domestic biocapacity is sufficient for them to become self-reliant if necessary, other densely populated countries such as the Netherlands, Germany, Israel, the UK and Japan could not exist at anything like their current material standards without trade flows from elsewhere and distant waste sinks. Japan and the Netherlands, for example, are running ecological deficits 7-10 times larger than their domestic biocapacities (WWF 2006), all made up by extra-territorial material flows.

My own research focus is entirely on consumers’ growing dependence on biophysical goods and services imported from ‘elsewhere.’ However, I also acknowledge the increasing dependence of producing countries on their export markets. Costa Rica, Canada and producers in any other countries rely on trade to generate economic activity and income. In Costa Rica the export share of total production by weight increased during the research period from 44% in 1989 to 74% in 2004. In Canada the export share of total production weight increased from 30% in 1989 to 47% in 2004. As will be discussed later in this chapter, this might also be problematic in light of global ecological trends (e.g. climate change, peak oil).

When the literature discusses the relationship between the wealthy North and the poorer South, it is usually in terms of the dependence of the south on the north (for markets that generate employment and foreign currency, and for investment capital needed for 'development'). While I acknowledge this form of dependence, one of the implications of the interregional ecology approach is the need to emphasize and study different kind of dependencies:
(1) <u>The dependence of the north on ecological goods and services from the south</u> – the increasing demand for imported commodities increases the reliance of consumers in the north on resources from the south. Moreover, several non-traded global ecological services required by people everywhere are provided by ecosystems in poorer countries (e.g., the climate modification services and biodiversity 'supplied' by tropical rain forests); (2) <u>The increasing dependence of the south on ecological goods and services from the north</u> – Historically, poorer countries were mostly self-sufficient but in recent years they have also become more dependent on imports, both as a result of increasing standards of living and to replace products that in the past were produced locally (but have now been abandoned as these countries shift production to commodities for which they have comparative advantage). While the U.S. relies on Costa Rica for several commodities, Costa Ricans are increasingly dependent on the U.S. for such products as grain and oil-seed; (3) <u>The dependence of every country, rich or poor on other countries, poor or rich.</u> – Consumers everywhere rely more and more on ecological goods and services produced elsewhere. While the U.S. external footprint is planted on many poor countries its largest footprint is on wealthy Canada and it also has a large footprint on other rich countries such as Australia and New Zealand.

A major implication of these increasing dependences is that the spatial scale for sustainability analysis and planning must be changed to match the scale of human economic activities. At present globalization tends to obscure inter-regional eco-deterioration and the need for more holistic planning. Since we are creating a global village and a global economy we must ensure that both are sustainable at the global scale. Approaching sustainability from a single spatial dimension (local, national or even global) as is most often done, is not enough. The analytic framework and practical examples based on these considerations and developed in this thesis should help convince the world community of the need to embrace an 'interregional human ecological' approach to sustainability. This requires formal acknowledgment that, in a globalizing world, no specified region can be sustainable if its distant supporting hinterlands—other regions that may be half a planet away—are not sustainable. The method presented here documents and quantifies some of these growing dependencies.

2) Continuous growth in such relationships has the potential to create unseen unsustainable burdens on productive ecosystems in distant locales: Most mainstream economists see free trade as a positive means to increases the well-being of all trading partners. Free trade is mostly seen as an important source of the wealth of economies and is promoted as a growth engine, a global wealth and prosperity creator. However, various researchers have argued that conventional trade theory is blind to the associated negative ecological consequences (e.g Daly and Goodland 1991; Madeley 1992; Andersson et al 1995; Rees 2002a; Daly and Farley 2004). Expanding trade flows accelerate the decrease of natural capital and increase the pace of ecological deterioration in exporting countries. To make matters worse, trade-dependent consumers are blind to the negative ecological effects of distant resource exploitation and production created in part by their own resource demands (e.g. Princen 1997; Conca 2002; Daly and Farley 2004; Rees 1994; 2002; 2004). Inhibiting knowledge, information, and contextual understanding of the ecological consequences of production process may further favour consumption and trade (Princen 1997; Conca 2001). In short, consumers lack the information and incentive to behave 'sustainably' even if they would otherwise be disposed to do so (Rees 1994; Princen 1997; Conca 2002). Thus, as the scale and scope of international trade increases so do the ecological consequences. Interregional ecological analysis assesses the degree to which producing products for export may be damaging the producer region. It helps to generate the missing feedback signal and reveal some of the presently hidden 'externalities' of free trade.

As discussed in chapter III conventional interpretations of globalization generally emphasize the benefits anticipated from greater economic integration (e.g., Helliwell 2002; Bhagwati 2004). Economists generally promote globalization as a mean to increase resource efficiency/productivity and thus to increase total wealth without necessarily increasing ecological impacts (Easterbook 1995; Simon 1996; Das 2004, Bhagwati 2004; Stiglitz 2006). Still, as partially documented here, globalization generates numerous 'externalities' that are mostly ignored and do not find their way into local / regional policy and planning. I argue that if we choose to live in globalized world we must ensure that it is sustainable over the long run for all members of the human family and for other species. For globalization to be a positive mechanism for sustainability the spatial scale for sustainability analysis and planning should match the scale of human economic activities and globalization itself should not be allowed to obscure inter-regional eco-deterioration. We need to make visible and eliminate those practices and processes that unnecessarily erode both the global commons and domestically-controlled resource assets in which we all have a stake.

One of my research objectives was to identify the linkages between material demands in importing regions and the loss of ecological structure and function in exporting regions. The cases studied here illustrate some of the potential and actual linkages between production for export and the change of ecological structure and function in exporting countries. The U.S. case documents the increasing terrestrial ecosystems area in specific countries required to support U.S. consumers' demand. The Costa Rican and Canadian cases show (true for any other case) that increasing production for export also involves increasing the amounts of physical inputs, e.g., land, water, chemicals and energy. By focusing on specific products and regions I was able to link export production to processes of land degradation including loss of habitat and biodiversity, soil erosion, and land and water contamination.

Other researchers have identified the need to examine the connections between human activities in one region and ecological changes in others. For example, Young et al. (2006) emphasize the need to find ways to identify, quantify and interpret the relationships between globalization and deterioration of supporting ecosystems; and Srinivasan et al. (2008) argue that we need to understand which nations are responsible for ecological deterioration in other nations' territories; they write: "Humanity has transformed our natural environment at an unprecedented speed and scale […] What we don't know is which nations around the world are really driving the ecological damages and which are paying the price." My study takes a step toward generating and documenting the linkages between consumption in one country and ecological changes in others. Interregional ecological analysis creates conceptual feedback so that consumers, businesses and governments can be made aware of the risks associated with the destruction of the distant ecosystems upon which they are increasingly dependent. It can help to raise public and decision-makers awareness of the connections between the sustainability of one region and that of others, and of their own interest in protecting and maintaining the distant ecosystems that support them.

3) Ecological degradation in one region has the potential to jeopardize the sustainability of other regions: My research suggests that such factors as climate change, 'peak oil', increasing population, higher demands for resources and geopolitical instability will make things more complicated for global sustainability, particularly for heavily trade-dependent societies. There is increasing evidence that severe weather phenomenon driven and accelerated by climate change will jeopardize the ability of producing regions to continue to support other regions. Two examples of producers are Australia and Canada: Australia is a major beef exporter to the U.S. as well as to other parts of the world; it is also the worlds' second wheat exporter; in recent years increasing drought in large parts of that country put at risk its ability to continue supporting the increasing demand for beef and grain. Canada is the world's largest wood products exporter; many countries depend on Canada's forests for their wood product needs. Climate change is increasing the number and the scale of forest fires in that country. It can also abet the spread of pests such as the mountain pine beetle which is currently destroying hundreds of thousands of hectares of productive forest in British Columbia and Alberta. Both these and related trends jeopardize Canada's ability to support future demand for forest products. These realities have implications for both the economic sustainability of local producing communities in Australia and Canada who depend on export production for their livelihoods and the welfare of consumers all over the world who import forest products from these countries. Furthermore, the degradation of ecosystems in Canada and Australia will redirect demand to still other ecosystems elsewhere, including tropical forests.

Another factor that might jeopardize trade-dependent regions is increasing oil prices as the world approaches the peak of oil production. As long as oil was abundant and its prices were low, specialized production and the transport of commodities across the world made sense (i.e., it is consistent with the idea of comparative advantage). However, as we approach —some argue we have already reached—the 'peak oil', oil prices will probably continue to rise making international trade more expensive and less attractive. The financial costs of dependence will increase, stifling growth and sustainability. This will negatively affect both those economies that relying on trade for income and those who need the traded resources.

Global population growth and the increasing number of affluent populations are pushing up the demand for resources, driving some ecosystems and other natural capital stocks beyond their productivity limits. Increasing competition for export commodities may exacerbate geopolitical tension as supplies dwindle and prices rise. For example, consider the effect of prevailing U.S. bio-fuels policy on its capacity to supply export markets with corn, grain and related products and the ability of poorer populations to access these commodities for their basic needs (e.g., food riots have resulted from the rising prices of corn tortilla flour in Mexico; in Pakistan the military has had to escort wheat shipments; increasing numbers of people worldwide cannot afford basic foods).

Population growth (mostly in poorer countries) is strongly connected to ecological pressure and damage to local ecosystems. However, in an interconnected world these 'local' ecological changes can contribute directly to global change that threatens human well-being elsewhere, even everywhere. Moreover, ecological degradation caused by rising local demand, may reduce the local ability to continue producing export products.

4) Consumers in any given region increasingly have interests in sustaining the ecosystems that support them in other regions: The processes described above suggest that consumers, businesses and governments all over the world have increasing interests in ensuring the sustainability of their supporting ecosystems in other regions. If, for example, the U.S. is increasingly becoming dependent on Canada for such vital resources as forest products and certain foods, then, arguably, the U.S. government has an interest, even an obligation to its citizens to ensure that the producer ecosystems (in Canada or in any other supporting country) remain viable. Similarly, if the production of export products in Costa Rica leads to deterioration of ecosystems in that country and risks different ecological services (e.g. biodiversity, climate mitigation) that also support the U.S. and many other countries, it should also be the interest of those countries to sustain those ecosystems in Costa Rica or in any other country that directly or indirectly support them.

The logic behind this kind of self-interest or practical responsibility includes increasing evidence that we are approaching the limits of planetary carrying capacity (Meadows et al. 1972; 2004; MEA 2005). The shift from an ecologically empty to an ecologically full world (Daly 1991), a world in which natural capital is becoming a limiting factor for human development and sustainability, can increasingly be connected to, geopolitical and security issues (Pirages and DeGeest 2004).

10.2.1 Locating an interregional ecology approach within the overall sustainability discussion:

Despite the increasing material entanglement of nations, the interregional approach to human ecological reality is still little appreciated and poorly documented in the sustainability debate. In chapter IV, I identify four major factors at the root of this under-appreciation: the uncritical acceptance of the dominant economic model; the prevailing local (versus global) perspective on sustainability; the lack of direct negative feedback; and the hallowed place of rising per capita income/consumption in industrial societies. Understanding the role of these four factors will enhance our understanding of the relationship between 'interregional ecology' and sustainability, challenge the mainstream approach to sustainability and suggest international development policies consistent with the approach developed here. For example: (1) By documenting external ecological footprints, quantifying the physical inputs associated with production for export, and revealing the linkages to ecological change, interregional ecological analysis can generate and deliver (at least conceptually) the negative feedback that, at present, mostly fails to reach consumers; (2) My research findings support the urgings of prominent ecological economists that the world's nations need to find ways to incorporate physical accounts of ecosystems goods and services (natural capital stocks and flows) into their systems of national accounts to support decision makers with a comprehensive picture of reality. Global society must consider material and energy balances and devise ways of keeping track of multiple material and energy flows. This is necessary if we are to come to a sufficient understanding the consequences of human activities on the ecosphere, both for the short and long run, and learn how different scales of human activities interact. I believe the theoretical approach and the empirical findings of my research make the first few steps in documenting the spatial dimension of such critical linkages and also contribute to the development of ecological economics. (3) My analysis emphasizes the need to move beyond local and single spatial dimension of ecological degradation to a global multi scale approach that acknowledge the linkages between sustainability in one place and the sustainability of others. (4) Interregional ecological analysis validates the view that we need to focus on the consumer's role (particularly over-consumption) in ecological degradation.

10.2.2 Some implications for sustainability policy and planning:

Interregional ecology can both provide an alarm mechanism that we are off track and serve as a driver for interregional sustainability policy and planning. The goal of the first is to facilitate the latter.

As noted, despite increasing global connectedness, most environmental policies presently apply to a single spatial scale, either local or national. The main emphasis is on pollution and waste as it impacts particular regions and in some cases the global commons. Moreover, most sustainability reports and programs are local or regional in scope. Even issues acknowledged to be global (e.g., climate change) are framed so that corrective action is essentially voluntary and fragmented among individual states (e.g., implementing Kyoto targets). However, in an ecologically interdependent full world, approaching or beyond biophysical limits (Daly 1991; Meadows et al. 2004), assessing and quantifying sustainability at a single scale is of limited effectiveness. Acknowledging the dependence of one country / region / city on resources in other region(s) and the ecological consequences of that dependence opens the door to 'interregional policy and planning'.

The analysis developed here can help provide the technical means for the international community to develop and implement more advanced, explicitly interregional policies and institutions for ecologically sustainable consumption. These policies are necessary to conserve at least "what there is" of remaining natural capital for future generations (Pearce et al 1989). Once the hidden effects of unconstrained trade have been exposed, the world community must turn its attention to assigning responsibility for the ecological knots in the tangled web of global relationships. A major problem is that of unaccounted ecological externalities. The many costs of ecological destruction due to production must be included in the price of both domestic and trade goods to enable resource exploiter / managers to maintain actual capital stocks.

But, how can we ensure full-cost pricing of traded commodities and manufactured goods? How can costs be assigned so that all parties dependent on the sustainable management of essential resources pay their fair share for that management? Global market forces increasingly assert their influence in every corner of the world, yet under increasingly competitive circumstances prevailing market prices do not reflect accelerating ecosystems degradation. In the absence of economic feedback and immediate biophysical feedback neither individual consumers, the corporate sector, nor governments have any incentive to reduce or redirect consumption (change lifestyles), implement corrective tax policies or develop more sustainable modes of production and consumption. Because of this fundamental weakness, the prevailing system of costs, prices, and market incentives fails absolutely to measure critical ecological scarcity or to determine the appropriate levels of natural capital stocks—the world community is suffering from an extreme form of market failure (Rees 1995; Daly 2001; Norgaard and Liu 2007).

There are ways to correct for this failure. Combined with data on the state of critical ecosystems, Interregional ecological analyses would enable identification of the economic processes and products most responsible for negative ecological change. Clearly, new international regulatory mechanisms and institutions will be required. These international agencies are necessary to 'internalize' previously ignored external costs and will supervise the implementation of different new international regulations. For example, we may have to place an absolute cap on exploitation of critical resources to insure sustainable harvest of renewable resources and the controlled extraction of non renewable resources in a way that matches the pace at which substitutions can be made. The allowable harvest / extraction could then be made available by governments or designated international agencies in the form, for example, of marketable transferable quotas. Revenues so generated would provide the basis for monitoring exploitation rates and for ecosystem restoration.

Other instruments for conservation and environmental quality enforcement whose implementation would be aided by interregional ecological analysis include nationally imposed resource depletion taxes, pollution charges and export taxes. In these cases too, revenues generated would be available for monitoring/enforcement and ecosystem restoration. The resultant higher costs would be passed on to consumers, thus providing needed negative feedback on unnecessary consumption. This in turn would stimulate both conservation and, by improving the relative position of competing products or processes, stimulate the development of alternative products and technologies. For example, within the research period the U.S imported a yearly average of 1,050,000 Mt of bananas from Costa Rica; a consumption tax of only 1 cent for each kg of Costa Rican bananas consumed in the U.S can annually generate about $10,500,000 that could be invested back into research and more sustainable and efficient methods of production in Costa Rica.

Other means have been employed to address the issue of eroding natural capital. For example, in recent years a series of international compensation agreements have been signed that involve payments to private land owners to maintain their land in its natural (mostly forest) state, i.e., not to convert it to more profitable uses (Several EU countries are involved in such payment to

Costa Rica). These agreements, though still small in scale, acknowledge the ecological services (e.g. biodiversity) people receive from overseas ecosystems and shows they are willing to pay for them. Documenting and highlighting interregional dependence can facilitate the spread of such compensation payment schemes.

Different modes of production generate different impacts. In recent years consumer protests and related activities by NGO's and governments throughout the world have led to increasing numbers of product certification projects that help to ensure the use of sustainable production processes. The main goal of certification is to identify products whose production methods generate less than conventional/minimal pressure on eco-systems. Interregional ecological analyses can help highlight the need for such programs by informing consumers in one region to ecological changes in other regions 'sustaining' them. Local or national governments in importing regions can encourage or even regulate the import of certified products.

A major potential policy application of interregional ecological analysis would be the formulation of new trade agreements and patterns. International trade produces negative ecological consequences, but it also benefits societies all over the world. It generates foreign currency, income and employment, which can facilitate better health, education, social support systems, and can improve certain aspects of the environment. Moreover, as the world's population increasingly urbanizes, it becomes impossible to support urban populations and densely populated urban countries on local domestic resources alone.

However, the increasing process of trade liberalization, supported and stimulated by regional and global free trade agreements and mechanisms (e.g. NAFTA, CAFTA, and WTO), is expanding interregional connections and reinforcing relationships that are inherently unsustainable for the many reasons discussed in this dissertation. While the WTO as well as NAFTA and other trade mechanisms include some environmental considerations that can limit the movement of goods and waste and protect consumers' health, they do not address the interregional issues raised by my research. They limit government interventions, do not support local production, increase exports and imports of ecologically significant goods/services and accelerate the entanglement among nations, all without creating mechanisms to provide importing regions with market or biophysical feedback on the state and sustainability of eco-systems in supporting regions.

Insight from an interregional perspective suggests that managed trade is necessary for sustainability. This recognizes the dependence of one region on resources in another and the negative consequences for both producers and consumers of resource over-exploitation. It identifies the ecological interests and responsibilities that must be shared between trading partners. Long term trade agreements should reflect these realities and require that the producers / exporters use sustainable modes of production (i.e., the U.S. will know the location of its footprints and may become involved directly or indirectly in managing those areas of terrestrial ecosystems (e.g., through import charges or consumption taxes designed to raised funds for improved ecosystem management in the exporting country). The higher costs of production will be passed on to importers and consumers. In this way producers and consumers will assume joint responsibility for management of key assets upon which they both depend in different ways.

It is clear that the growth-oriented, competition-based global community is a long way from accepting the need for such new regulatory regimes and the partial loss of national sovereignty of resource development that they imply – national sovereignty in resource management still trumps international concerns in contemporary international environmental law. One can only work to ensure that this situation evolves as the human family comes to recognize and acknowledge its mutual dependence on ecosystem goods and life-support services currently managed under national jurisdictions and subject to overexploitation under prevailing management regimes. Acknowledging the dependence of one country / region / city on resources in other region(s) can facilitate interregional sustainability planning. Meanwhile, specific countries can lead the way by incorporating interregional connections into their domestic policy and planning. Indeed it is important to incorporate an interregional assessment into local planning. Perhaps then planning processes will move beyond the local or regional scale and will incorporate the areas that support the specific city or region. Even urban level planning should begin take into account the city's dependence on distant hinterlands wherever on Earth they are (Rees 2003; Kissinger and Haim 2007). If cities are unable to affect the management of imported 'land' they can at least begin better to husband productive ecosystems in their immediate vicinity (e.g., would avoid the 'urbanization' of peri-urban cropland in case climate change or geopolitical strife requires their future use in local consumption for local production).

The point is that as long as commodities arrive unimpeded from far away at lower prices than local production, the felt need to maintain local production is minimized And local agricultural land, for example, is then pressed into more profitable uses. However, once we acknowledge our dependence on other regions whose reliability is threatened by exogenous forces, the need for a precautionary approach to maintaining local stocks of natural capital becomes self-evident. While urban areas around the world occupy only about 2% of the earth's terrestrial areas, many urban areas all over the world are built on productive lands. For example according to Statistics Canada (2001) from the 1970s to mid 1990s Canada lost 1,200,000 ha of agricultural land to urban uses, a trend that may have serious consequences if foreign supplies suffer significantly from ecological changes. That issue is even more crucial in smaller countries where the abundance of productive land is shrinking due to the move to other uses of land.

10.2.3 Promoting Sustainability Science:

In the following paragraphs I identify some of the contributions and research implications of my work for future sustainability research. I suggest that acknowledging the linkages between the sustainability of one region and that of others adds an important dimension to the discussion and research of sustainability and contributes to the emerging field of Sustainability Sciences.

10.2.3.1 Sustainability assessment tools:

Material Flows Analysis (MFA); Life Cycle Assessment (LCA); Physical Input Output Tables (PIOT); and Ecological Footprint Analysis (EFA) have all contributed to the ideas behind interregional ecology as well as to some of the technical data required for this study. These tools have several properties in common: first, they perceive the connections between human activity and the natural environment in terms of both resources (i.e., material and energy inputs) and wastes. Second, these tools reflect a "whole process" approach to either production- or consumption. They measure not only economically-relevant flows but also identify indirect effects and potential impacts. Third, each method can be implemented at different spatial scales (local to global) or at the product, sectoral or whole industry level.

At the same time, my research contributes to each of these important sustainability assessment tools. While these methods are all fairly comprehensive, most actual applications ignore two major dimensions of interregional ecological analysis. They usually fail to identify either the geographical source(s) of trade goods or the ecological consequences of the production-consumption chain, particularly those occurring at the source of raw materials. My research takes the first steps in addressing these issues by tracing some of the sources of material flows, disaggregating and locating the ecological footprints and making some of the correlations to specific ecological changes. The dissertation contributes the most to ecological footprint analysis (EFA). EFA is unique in that it associates the material demands of human activities to the corresponding terrestrial and aquatic ecosystem area ‘appropriated’ to supply that demand. Still standard EFA does not reveal where study population footprints are located and what the specific ecological consequences of that footprint are. In this dissertation I show the advantage of disaggregating the EF and develop a method to document the location and the size of the footprint of several countries on others specific countries.

10.2.3.2 Focusing on the physical volume and not only on the economic value:

Conventional economic indicators focus on the monetary contribution of different economic sectors and activities. Following these indicators, in the two exporting cases studied here (Costa Rica and Canada) the role of agricultural activities as part of the overall economy, and in generating foreign currency and employment has been in decline in recent decades. However, embracing the method developed here shows that in both cases the volume of production as well as the amount of physical inputs involved are steadily increasing. Thus, in assessing of trade relationships and sustainability generally, conventional economic indicators are not sufficient; this research illustrates the different picture that is revealed when the volumes of physical inputs and outputs of agricultural activities are quantified.

Most trade data sources document the value of traded commodities and ignore the volume or weight. Therefore the importance of some high volume/weight commodities might be overlooked due to their low economic value (e.g. certain minerals compared to palm oil or certain grains. Focusing on the value of trade goods does not tell us much about potential ecological consequences of producing specific products or commodities. Moreover, even data sources that do document the volume and weight of trade flows document the weight that enters and exits the importing country and ignore the fact that production of many products involve much larger quantities of raw products (e.g., producing a certain quantity of ketchup involves larger quantities of tomatoes, etc.). Also production of those traded goods involved an extra amount of physical inputs which are devoted for that production. In this dissertation I transform production quantities for export / import back to their raw / fresh quantities and quantify some of the inputs involved.

These insights highlight the contribution of this dissertation toward generating a more comprehensive environmental accounting and sustainability assessment tools.

10.2.3.3 The challenge of working with large data sets:

A unique contribution of this dissertation is the documentation, analysis and synthesis of data from different fields. When analyzing interregional connections many kinds of data and data sources must be employed. Moreover, to describe and quantify interregional material linkages and to investigate the correlations to ecological changes requires an interdisciplinary approach.

The use of data from different fields, focusing on different scales, opens a discussion on the potential and limitations of data for documenting interregional connections. The discussion on data involves such aspects as: accessibility to data; analysing interdisciplinary data; and analysing data across scales.

Accessibility to data: I used several kinds of data to document and empirically test the interregional approach to sustainability (Chapter VI). Data availability played a major role in my ability to explicitly document these connections. My research efforts revealed that some processes are documented better than others and that the availability of data can be a major constraint for such study. For example while data on production and trade flows are relatively well documented and accessible, data on processes of ecological changes are more sporadic, and some aspects are covered better than others. Moreover, while some data are documented on a monthly or yearly basis, other data are sparely documented or do not exist at all.

Analysing interdisciplinary data: A major challenge of this research was to bring together data from very different sources, including data from the social sciences (e.g., trade and consumption data); the agricultural sciences (e.g., chemical inputs; water inputs; soil erosion); the natural sciences (e.g., biodiversity loss, water contamination); and from several environmental reports. As the focus of each of these disciplines is different, so are the kinds of data they document. Therefore, it is often difficult or even impossible to make correlations between data from different sources. Moreover, the varied purposes of documenting different data usually have nothing to do with finding correlations to other processes, for example: trade data are generally not gathered to be connected to data on ecological changes; ecological studies on biodiversity are usually documented for the sake of science and mostly do not investigate the human activities that might jeopardize that diversity.

Analysing data across scales: Another major challenge, strongly connected to the two above, is analysing data across scales. While some data were available at the national scale (e.g., trade data), the foci of other data were on very small scales such as specific fields or forests and in many cases, as in many studies in the natural sciences, on a single or a group of research plots.
To overcome some of the data constraints I embraced a multi-scale approach and documented some interregional connections for each scale and substantive focus: import, export, and specific regional and product connections. This approach allowed me to focus on each scale separately and to make some correlations between them. The data used for the import and export dimensions were mostly at the national level and involved quantitative data at that scale – including data on production, physical inputs, trade data, consumption levels etc. I then used data on processes of ecological changes at the national and regional scales. The third scale was the the specific product / regional spatial scale. I used data from the agricultural and natural sciences to make the correlations between specific production activities and ecological changes (e.g., bananas and deforestation). The lack of comprehensive data did not allow me to document some processes in great detail or make more explicit connections.

Ideally, in the future data sources will be expanded and the gaps between existing and required data will be narrowed. For data to be more comprehensive I suggest an expansion of data on production, trade, consumption and ecological changes. For example: production data could be documented together with physical inputs involved (e.g., land, energy, chemicals). Trade data would cover both the traded quantities (in weight or volume) and the raw or fresh equivalent of those traded quantities (e.g. the fresh tomatoes weight required for certain traded weight of ketchup). Consumption data would allow us to trace back a product consumed in any country to the specific region in exporting country the consumed product was produce. Data on ecological changes would include multi spatial scales from the field / plantation scale through the regional to the national scale. These data would document change of eco-systems structure and function and would correlate those changes to specific activities.

10.3 Suggested areas for further research

This dissertation investigates only a small part of the extremely complicated interregional relationships in a globalizing, increasingly interconnected world. I have taken only the first steps in exploring and documenting some aspects of an interregional human ecological approach to sustainability. Future research should deal with expanding the data-base, broadening the concept, identifying specific priority areas of concern (e.g. critically threatened natural capital assets), revising trade agreements, and otherwise providing a firm basis for specific policy and planning tools and new international institutions.

Expanding the data base: (I) Data availability is a major constraint in documenting the flow of resources and especially of processes of ecological changes and the correlations between the two. In the future I intend to expand the data-base to include other countries and ecological consequences. Moreover, I hope to be able to collaborate with other researchers from the relevant fields to be able to make the correlations between physical inputs and ecological changes stronger. (II) In this study my focus was on renewable resources, however future research should include the flow of non renewable resources as well. These resources play a major role in international trade and create major impacts on eco-systems all over the world. (III) I followed here such sustainability measurement tools as MFA, LCA, EFA, and PIOT (Chapter V). Ideally, material flows and LCA should have access to data that would enable them to specify the geographic origins, rates of extraction and total quantities of resources consumed, as well as the quantity of inputs (e.g., land, water, chemicals, energy) involved in the extraction / production process. However, in this research I mostly document land inputs; other physical inputs are only partially documented. Future research should expand the scope to document other inputs as well.

Tightening the correlations between specific production and ecological changes: To document fully the nature of interregional connections, analyses of sector-wide or product-specific energy and material flows should be combined and integrated with other analyses to identify and deconstruct the ecologically significant relationships among interdependent regions. As matters stand, no single method (i.e. MFA, LCA, or EFA) adequately links product production / consumption to ecological change. Analysts are usually forced to rely on state of environment reports and other environmental studies – environmental impact assessment, land use reports, etc., – to infer causal links between their material flows or LC analyses and ecological degradation. These independent environmental reports have different purposes but, in the interim, each can contribute to documenting the relationships between resource demand, product consumption and ecological change. Future study should continue to develop this database by expanding the available data for each of the discussed tools.

Different scales: While the current study focuses on the interactions between nations, interregional connections also exist within countries. Urbanites, for example, depend utterly on the flow of resources from outside the boundaries of their cities – from nearby regions, other parts of the country and as documented here, other countries. In the future I intend to document these connections as well. This will increase the potential interregional local policy and planning.

Broadening the concept: I distinguished in this thesis among three strands of interregional thinking: The conventional production strand; the local production and consumption strand; and the trade flow strand. My work focused empirically the trade flow strand. Future study should further develop this strand its interactions with the others. A few examples would be: (1) Trade-related factors – As shown in this dissertation, trade can be associated with several kinds of direct ecological impacts in exporting countries. However, trade between two countries indirectly risks the interests and sustainability of other countries as well. For example the accelerating deforestation of Brazil's Amazon basin is increasingly associated with the expansion of soybean production (partially stimulated by the conversion of US soy lands to corn production for bio-ethanol—another interregional connection) for export to China (Hanson and Martin 2006). However, this deforestation indirectly reduces the sustainability of other countries to the extent they are dependent on the integrity of the Amazon rain forest for climate mitigation and as a biodiversity preserve. (2) Local drivers and trade flow interactions – Many local ecological impacts result from strictly local activities. Still, such impacts may eventually reduce the ability of country 'A' to continue producing export products and therefore risks the sustainability of both producing country 'A' and consuming regions 'B,' 'C' and 'D.' For example water mismanagement in the US Southwest and in California, combined with climate change, threatens California's cropland, a major source of North America's table vegetables. (3) Local drivers and global change – Some local activities or events contribute directly to global change that threatens sustainability elsewhere or everywhere. For example, forest fires in Canada and Indonesia contribute to greenhouse gas accumulation and thus accelerate global climate change; deforestation for any economic purpose anywhere also contributes to biodiversity loss which is ultimately a global issue; the local use of toxic chemicals can lead to dangerous accumulations in distant food chains, putting predatory birds and mammals, including humans at risk.

Providing a firm basis for specific policy and planning tools and new international institutions: Interregional ecology can help provide the technical means for the international community to develop and implement more advanced, explicitly interregional policies and institutions for sustainable consumption. While the major emphasis of this dissertation is on the conceptual and technical dimensions of interregional flows, I intend to focus future research specifically on specific policy implications; analyzing in depth existing and potential future mechanisms; identifying and highlighting existing and new international institutions required to implement sustainability in an interconnected world.

To reiterate, in a globalizing increasingly interdependent full world, approaching or beyond biophysical limits, activities in any region have the potential to impact the structure and function of ecological systems in other regions. The processes of globalization and international trade, while contributing to economic growth and human well-being in much of the world, have also dramatically increased the degradation of critical ecosystems and related life-support functions on every continent. For sustainability, the global community should ensure that globalization does not buffer consumers from the negative impacts of material-intense lifestyles, that it does not short-circuit the negative feedback from over-exploitation of supportive ecosystems. For sustainability in such a world a more explicitly interregional analytic framework should be embraced, one based on recognition that sustainability anywhere is linked, directly and indirectly, to sustainability elsewhere. Interregional human ecological analysis as advanced here can help restore the missing negative feedback about our actions, highlight our dependence on others and emphasize our interests in sustaining resource flows and their corresponding ecosystems. For sustainability in such a world we must make sure that what is out of sight is not out of mind, that what is far from the eye is not far from the heart.

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APPENDICES

Appendix 1 table 1: Resource Commodities Included in the Research

Apples	Fresh	Dried	Preserved	-	Juice	**Ginger**	Fresh	-	-	-	-
Apricots	Fresh	Dried	Preserved	-	-	**Lettuce**	Fresh	-	-	-	-
Avocados	Fresh	-	Preserved	-	-	**Mushroom**	Fresh	Dried	Preserved	Frozen	-
Bananas	Fresh	Dried	-	Frozen	-	**Okra**	Fresh	-	-	Frozen	-
Blueberries	Fresh	-	Preserved	Frozen	-	**Onions**	Fresh	-	-	-	-
Other berries	Fresh	Dried	Preserved	Frozen	-	**Potatoes**	Fresh	-	Preserved	Frozen	Flakes
Strawberries	Fresh	-	Preserved	Frozen	-	**Peppers**	Fresh	-	Preserved	-	-
Cherries	Fresh	-	Preserved	Frozen	-	**Spinach**	Fresh	-	-	Frozen	-
Dates	Fresh	-	Preserved	-	-	**Tomatoes**	Fresh	Dried	Preserved	Ketchup	Paste
Figs	Fresh	-	Preserved	-	-	**Yam**	Fresh	-	-	-	-
Grapes	Fresh	Dried	Preserved	-	Juice & wine	**Wheat**	Raw	Flour	Pasta	-	-
Grapefruits	Fresh	-	Preserved	-	Juice	**Rye**	Raw	Flour	-	-	-
Kiwis	Fresh	-	-	-	-	**Oat**	Raw	-	-	-	-
Lemons	Fresh	-	-	-	Juice	**Maize**	Raw	Flour	Preserved	Frozen	-
Mangos	Fresh	Dried	Preserved	Frozen	Juice	**Rice**	Raw	Flour	-	-	-
Melons	Fresh	-	-	Frozen	-	**Millet**	Raw	-	-	-	-
Olives	Fresh	-	Preserved	-	Oil	**Barley**	Raw	-	-	Malt	Beer
Oranges	Fresh	-	-	-	Juice	**Almonds**	In shell	No shell	Preserved	-	-
Papayas	Fresh	Dried	Preserved	Frozen	-	**Brazil nuts**	In shell	No shell	Preserved	-	-
Pears	Fresh	-	Preserved	-	-	**Cashews**	In shell	No shell	Preserved	-	-
Peaches	Fresh	Dried	Preserved	-	-	**Hazelnuts**	In shell	No shell	-	-	-
Pineapples	Fresh	-	Preserved	Frozen	Juice	**Pistachios**	In shell	No shell	Preserved	-	-
Plums	Fresh	-	Preserved	-	-	**Coffee**	Green	Roasted	-	-	-
Watermelons	Fresh	-	-	-	-	**Tea**	Raw	-	-	-	-
Beans	Fresh	Dried	Preserved	Frozen	-	**Cocoa**	Raw	Paste	Butter	Powder	-
Chickpeas	Fresh	Dried	Preserved	Frozen	-	**Sugar**	Raw	Refined	Cane	-	-
Lentils	Fresh	-	-	Frozen	-	**Flaxseed**	Raw	-	-	-	Oil
Peas	Fresh	Dried	Preserved	Frozen	-	**Groundnuts**	In Shell	No Shell	Preserved	-	Oil
Asparagus	Fresh	-	Preserved	Frozen	-	**Mustard**	Raw	-	Preserved	-	Oil
Broccoli	Fresh	-	-	Frozen	-	**Soya**	Raw	Flour	Preserved	Sauce	Oil
Cabbage	Fresh	-	-	-	-	**Sunflower**	Raw	-	-	-	Oil
Carrots	Fresh	-	Preserved	Frozen	-	**Palm**	Fresh	-	-	-	Oil

Table 1 (continued)

Cauliflower	Fresh	-	-	Frozen	-	**Rapeseed**	Raw	-	-	-	Oil
Celery	Fresh	-	-	-	-	**Safflower**	Raw	-	-	-	Oil
Cucumbers	Fresh	-	Preserved	-	-	**Sesame**	Raw	-	-	-	Oil
Garlic	Fresh	-	-	-	-	**Beef**	Live	Fresh	Frozen	Salted	Processed
						Lamb	Live	Fresh	Frozen	-	-
Wood	Logs	Lumber	Plywood	Pulp	Paper	**Sisal**	Raw	Processed	-	-	-
Cotton	Raw	Yarn	Apparel	Furnishing	-	**Tobacco**	Raw	-	-	-	-
Jute	Raw	Yarn	-	-	-	**Cassava**	Raw	-	-	-	-
Rubber	Raw	-	-	-	-						

Appendix 1 table 2: U.S. Agricultural Import (fresh or raw equivalent weight – metric ton/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Fruits	10,083,880	11,340,360	11,739,570	11,971,940	13,711,570	13,385,140	12,735,360	13,203,860	14,491,500	14,247,320	16,172,450
Grains	5,685,510	5,202,760	6,802,170	6,318,640	6,618,680	6,115,120	6,871,710	6,311,570	5,362,440	5,688,690	5,483,620
Legumes	179,210	176,360	211,800	212,700	238,300	262,550	317,680	392,930	401,730	451,730	433,610
Nuts	80,150	220,790	247,980	248,920	278,070	314,510	322,440	363,880	392,640	498,640	448,760
Oil crops	7,612,040	9,085,670	9,969,300	9,501,730	11,701,530	10,701,300	10,209,920	10,881,760	12,593,580	15,390,510	14,744,060
Stimulants	16,318,660	28,590,920	28,788,570	20,834,850	16,899,280	15,860,730	14,536,190	14,747,000	16,095,020	15,787,310	21,865,420
Vegetables	2,907,250	3,314,420	3,487,270	4,064,500	4,246,440	3,984,920	4,373,610	4,795,990	5,143,370	5,458,420	5,487,470
Fibers	2,025,220	2,085,710	2,262,810	2,427,580	2,457,660	2,704,960	2,477,130	3,046,770	3,152,910	3,315,980	3,294,660
TOTAL	**44,891,910**	**60,017,000**	**63,509,460**	**55,580,850**	**56,151,530**	**53,329,210**	**51,844,050**	**53,743,770**	**57,633,180**	**60,838,580**	**67,930,040**

Appendix 1 table 3: U.S. Agricultural 'Land Import' (total hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Fruits	662,450	666,880	690,010	737,540	787,680	779,110	740,140	820,010	855,780	852,030	966,350
Grains	2,258,920	1,903,260	2,819,320	2,528,150	2,407,930	2,359,580	3,102,680	2,909,070	2,123,430	1,990,400	2,101,670
Legumes	97,880	87,510	111,870	106,580	116,600	143,470	178,680	234,590	215,730	261,920	251,720
Nuts	180,080	479,840	645,990	1,132,890	578,200	704,170	736,610	674,060	700,130	854,020	668,900
Oil crops	2,130,320	2,222,100	2,489,840	2,447,640	2,446,060	2,553,300	2,802,540	2,588,550	2,514,570	3,298,240	2,778,750
Stimulants	3,401,930	3,791,760	3,762,880	3,685,660	3,806,660	3,857,280	3,512,410	3,057,280	3,473,820	3,458,310	3,637,820
Vegetables	193,700	222,040	235,550	269,690	288,110	284,210	337,990	364,240	379,350	403,180	409,560
Fibers	2,784,070	2,865,340	3,328,570	3,617,220	3,410,430	3,973,160	4,528,960	5,367,620	6,117,170	6,153,920	6,172,260
TOTAL	**11,709,340**	**12,238,730**	**14,084,030**	**14,525,360**	**13,841,660**	**14,654,280**	**15,940,010**	**16,015,410**	**16,379,982**	**17,272,015**	**16,987,030**

Appendix 1 table 4: U.S. Agricultural Import by Country (fresh or raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	1,576,270	2,022,480	2,387,560	2,337,220	1,393,950	1,512,920	1,716,640	1,920,320	1,562,800	1,621,630	1,839,670
Australia	1,310,340	2,469,820	1,276,540	1,453,930	847,590	971,210	995,490	1,112,920	984,520	1,114,720	1,254,990
Bahamas	21,840	21,870	21,960	14,100	14,690	12,410	31,100	26,530	27,210	17,010	14,390
Belize	185,210	285,250	485,910	272,820	218,040	261,960	449,880	463,040	406,840	299,360	329,230
Bolivia	150,240	92,800	167,780	107,000	81,440	64,840	85,020	162,580	85,490	93,340	164,930
Brazil	3,025,660	5,329,400	4,978,900	3,649,570	3,971,820	3,252,800	3,618,660	2,565,370	3,586,500	3,497,430	5,541,260
Burundi	4,950	200	4,160	2,670	3,050	4,440	1,910	830	5,450	170	2,580
Cameroon	11,710	14,730	12,900	7,450	6,320	10,540	5,360	12,270	13,860	12,510	15,020
Canada	7,433,340	7,634,610	8,960,030	8,674,090	9,388,170	9,497,090	9,884,580	9,067,220	8,701,940	9,764,700	9,489,750
China	270,620	313,740	412,230	516,270	570,700	611,360	697,240	985,690	1,652,820	1,997,180	2,090,390
Chile	638,330	790,600	761,710	785,160	1,120,060	948,430	1,038,030	1,119,960	1,280,070	1,187,010	1,309,640
Colombia	2,202,530	1,691,130	2,306,950	1,164,790	1,677,380	1,438,420	1,225,550	1,584,610	2,149,800	1,910,530	1,594,200
Congo	0	50,740	216,700	0	64,120	64,730	0	64,730	64,840	64,850	64,700
Costa-Rica	1,474,690	2,778,700	2,152,710	2,587,630	2,876,250	2,803,740	2,051,900	1,882,250	2,287,980	2,990,610	2,188,590
Dominican Republic	1,812,770	3,217,930	4,595,170	2,849,030	1,454,210	1,969,650	1,557,640	1,737,120	1,809,760	1,774,250	1,765,050
Ecuador	1,182,570	1,370,740	1,012,490	1,278,200	1,389,870	1,175,450	1,150,170	1,124,420	1,219,280	1,177,150	1,153,540
Egypt	51,220	34,330	45,320	63,550	48,490	65,170	69,580	69,210	75,060	57,740	57,860
El- Salvador	554,920	970,550	973,780	907,770	600,640	636,620	778,070	548,800	761,730	632,330	1,255,150
Ethiopia	6,520	8,210	18,470	14,340	7,900	10,730	9,880	9,150	8,510	10,360	11,650
Ghana	35,300	22,890	7,690	16,080	33,820	69,520	58,010	29,920	15,420	24,550	33,320
Greece	52,290	38,600	49,260	44,090	30,000	41,960	37,300	39,220	41,880	31,880	36,490
Guatemala	1,617,400	3,568,460	3,506,570	2,168,700	4,113,820	2,512,750	1,984,770	2,190,920	3,602,030	2,987,900	3,514,320
Haiti	13,830	12,320	14,070	11,480	12,060	12,580	8,350	11,420	10,050	11,530	12,750
Honduras	896,440	942,760	1,050,500	1,015,110	367,510	576,560	813,400	770,750	905,700	934,230	1,173,160
India	269,460	499,680	549,080	632,890	518,720	559,380	542,830	697,640	674,160	1,127,910	682,810

Table 4 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Indonesia	1,962,490	3,420,090	3,171,440	2,228,270	3,598,660	2,920,130	1,411,870	1,335,710	1,555,310	2,471,840	3,171,260
Ivory Coast	128,870	252,660	245,170	263,910	242,340	429,900	220,180	172,470	228,800	315,830	470,170
Israel	65,000	50,250	38,990	53,380	68,270	31,020	36,300	38,750	38,470	37,200	40,340
Italy	788,420	810,740	1,163,300	1,202,770	1,112,580	1,694,360	1,625,410	1,634,050	1,518,720	1,547,730	1,649,680
Jamaica	47,050	361,420	317,330	153,750	108,400	6,120	3,140	2,790	2,800	103,940	27,620
Kenya	6,630	11,770	11,170	10,230	8,690	9,986	10,970	10,600	9,360	8,320	9,120
Madagascar	66,850	600	210,610	9,040	69,940	67,340	60,070	52,730	860	1,00	140
Malaysia	3,679,940	3,752,620	4,629,150	4,875,430	5,843,930	5,194,530	5,769,830	6,169,480	7,405,410	7,660,430	7,932,990
Malawi	11,880	181,220	121,650	129,160	118,220	21,820	210,280	106,810	114,380	97,030	69,860
Mauritius	28,080	215,070	217,510	309,990	46,880	50,170	112,260	30,620	19,090	194,890	39,680
Mexico	3,751,810	4,145,170	4,197,070	4,895,770	5,165,990	4,663,770	5,000,140	5,661,650	4,147,060	4,433,600	7,096,660
Mozambique	430,920	228,870	549,200	188,720	80	240,730	117,100	122,370	120,360	122,020	134,850
New Zealand	56,120	75,260	128,230	75,250	94,350	141,860	133,820	100,190	89,770	117,150	70,850
Nicaragua	328,160	893,100	1,230,890	762,330	356,520	574,020	130,180	266,400	355,620	527,960	868,680
Nigeria	26,940	23,010	13,190	7,990	5,300	1,390	2,200	5,550	23,730	5,230	34,130
Pakistan	145,910	172,700	231,970	308,720	331,030	431,910	447,240	497,620	525,460	613,710	611,710
Panama	642,680	817,480	859,760	605,350	682,320	652,720	462,530	363,430	374,140	248,040	678,960
Paraguay	139,550	31,090	35,260	93,750	75,760	69,760	69,390	65,460	66,760	82,130	122,310
Papua New Guinea	81,910	13,410	74,050	84,760	98,380	79,820	25,150	148,080	79,900	86,330	85,550
Peru	724,370	818,680	723,640	767,870	351,280	343,200	732,990	596,000	587,970	617,880	560,060
Philippines	1,864,650	2,933,200	3,463,140	2,247,280	1,864,890	1,417,510	1,494,090	1,288,470	2,048,970	1,829,270	1,796,850
Rwanda	290	2,960	940	850	890	1,460	3,570	2,300	2,180	3,210	3,090
South-Africa	271,420	1,239,550	252,740	711,690	201,960	504,930	74,590	673,100	319,900	276,290	350,680
Spain	191,400	196,660	270,830	305,410	332,180	349,690	362,740	470,750	420,690	435,100	454,200
Sri Lanka	5,860	4,970	3,870	5,170	5,280	4,760	3,810	4,030	4,420	4,410	4,800
Tanzania	3,940	1,870	1,030	1,260	1,630	2,420	1,640	950	2,310	3,440	2,730

Table 4 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Thailand	1,151,560	1,246,910	1,211,750	1,082,700	1,206,200	1,250,250	1,224,580	1,180,860	1,285,640	1,360,990	1,311,570
Turkey	243,170	231,800	207,520	204,840	274,940	226,650	290,980	207,080	218,460	223,030	264,370
Uganda	3,680	7,520	14,370	5,120	11,800	9,170	8,190	5,630	10,500	6,980	5,820
Uzbekistan	100	100	100	100	100	100	100	100	100	110	110
Venezuela	15,090	43,940	19,630	23,170	35,930	19,430	14,200	22,300	20,170	20,020	15,370
Vietnam	61,320	103,860	148,720	143,510	104,290	196,910	228,640	206,670	227,490	337,880	333,010
Zimbabwe	150,330	566,220	314,670	46,840	126,080	116,480	127,870	230,600	6,400	109,570	111,960

Appendix 1 table 5: U.S. Agricultural ‘Land Import’ by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Costa Rica	91,073	103,737	90,751	98,626	99,308	99,765	94,099	100,991	108,628	135,155	109,213
Dominican Republic	252,138	270,241	284,773	255,065	151,525	164,268	156,197	135,440	163,918	135,055	113,553
Ecuador	397,534	375,141	360,924	318,136	282,802	247,565	268,423	176,111	230,403	161,564	127,122
Egypt	63,287	38,426	47,833	91,707	57,302	63,092	195,787	97,079	134,799	42,603	42,694
El-Salvador	32,344	40,735	55,863	57,555	45,449	114,001	58,700	61,540	73,358	74,599	67,908
Ethiopia	7,092	8,931	20,286	17,991	11,315	18,184	15,575	12,485	10,499	12,387	12,832
Ghana	83,140	54,286	19,664	49,448	94,219	225,818	178,501	71,658	17,369	36,441	58,096
Greece	23,158	18,617	22,531	21,330	15,148	18,925	17,894	18,032	22,784	16,969	19,459
Guatemala	183,753	201,917	190,283	163,162	197,531	202,617	175,080	170,561	198,948	174,413	192,780
Haiti	8,783	8,989	8,831	9,313	6,883	5,979	5,746	7,366	8,264	8,424	8,274
Honduras	55,385	54,624	55,481	77,481	51,253	91,326	75,595	55,157	55,429	64,732	63,099
India	731,923	869,580	1,160,137	1,246,740	1,328,963	1,555,003	1,524,571	1,781,026	1,251,760	1,896,997	1,518,898
Indonesia	1,169,101	1,403,326	1,482,515	1,448,395	1,371,073	1,327,572	1,181,468	1,241,870	1,307,412	1,504,410	1,623,235
Ivory Coast	241,225	388,409	313,470	432,244	346,253	406,636	300,936	233,422	307,227	429,174	550,585
Israel	1,154	2,217	1,381	1,412	1,557	1,140	1,311	1,217	2,208	1,772	2,427
Italy	216,189	297,672	275,545	364,820	237,093	493,448	468,195	481,461	441,000	350,035	389,994
Jamaica	3,433	8,022	6,785	3,668	3,107	928	829	637	518	2,858	1,078
Kenya	7,430	13,103	18,835	19,075	12,287	11,482	21,467	18,879	20,854	17,405	16,324
Madagascar	205,616	204,316	230,953	226,630	207,631	357,556	568,546	542,148	541,976	2,844	307,812
Malaysia	415,783	401,092	493,818	510,911	582,319	604,390	559,497	565,971	608,418	617,486	610,622
Malawi	9,394	18,756	19,181	11,806	26,811	24,361	29,751	49,524	35,031	39,633	41,256
Mauritius	392	2,936	2,736	3,968	875	717	1,419	454	263	2,642	549
Mexico	752,338	837,844	716,042	873,610	933,141	877,667	732,641	717,430	626,292	660,014	753,797
Mozambique	35,913	18,215	47,713	12,858	94	16,567	8,128	9,405	9,319	9,444	10,156
New-Zealand	1,783	2,616	3,725	2,808	3,574	5,315	5,490	4,572	6,228	11,321	6,370
Nicaragua	16,432	27,925	40,087	41,830	25,086	52,870	62,280	56,754	47,462	80,289	52,746

Table 5 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Nigeria	61,186	35,159	19,885	12,664	10,798	1,969	4,441	14,968	63,555	8,595	94,560
Pakistan	231,859	329,648	425,081	579,903	495,651	665,963	752,235	781,823	891,452	780,820	785,525
Panama	35,196	31,181	33,265	27,756	39,483	30,178	26,020	18,022	22,726	16,845	26,202
Paraguay	3,034	648	855	1,942	1,614	1,847	1,741	1,387	1,348	2,000	4,390
Papua New Guinea	32,421	23,556	17,096	51,611	76,554	27,064	45,821	41,624	20,363	41,811	39,459
Peru	73,064	55,384	86,784	93,514	93,939	103,174	90,696	94,609	95,362	95,077	84,445
Philippines	66,567	72,366	71,329	60,272	54,764	49,651	52,207	48,121	63,450	47,253	43,187
Rwanda	404	4,755	1,313	1,145	1,262	2,053	5,060	3,278	3,132	4,655	4,094
South-Africa	7,671	22,915	15,963	17,613	11,413	20,746	15,082	25,179	20,971	14,116	14,456
Spain	196,762	81,310	86,024	125,681	153,602	140,148	116,403	219,421	129,450	136,493	144,864
Sri-Lanka	14,045	13,286	16,629	9,400	9,433	6,774	5,512	10,768	10,859	12,976	16,479
Tanzania	2,774	1,856	2,164	2,953	2,949	4,677	3,352	1,964	5,111	5,499	5,365
Thailand	358,958	352,294	374,418	379,906	361,515	434,623	401,803	455,309	405,569	448,645	399,891
Turkey	205,498	169,920	246,439	179,986	274,744	166,806	271,403	182,514	198,320	165,577	217,299
Uganda	5,333	7,308	17,793	6,621	12,880	19,245	10,957	6,484	18,368	9,900	8,254
Uzbekistan	113	81	260	833	7,679	26,889	712,014	951,566	1,857,344	1,858,250	1,858,250
Venezuela	19,054	80,961	24,237	38,710	74,561	21,915	14,915	43,500	42,267	40,474	24,547
Vietnam	44,962	55,515	60,228	75,318	57,391	126,872	131,288	132,048	127,925	170,950	187,465
Zimbabwe	2,655	13,550	8,353	5,416	14,939	4,279	9,415	18,213	8,672	5,655	2,428

Appendix 1 table 6: U.S. Fruit Imports by Commodity (fresh equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Apples	1,432,380	1,623,322	1,707,013	1,622,427	1,878,000	1,871,438	2,082,095	2,106,690	2,387,532	2,492,640	2,861,579
Apricots	81,785	74,537	67,863	75,197	84,793	91,832	90,626	95,333	82,622	90,208	81,611
Avocados	33,881	40,539	40,434	76,581	74,225	101,410	95,119	147,868	170,421	184,404	303,128
Bananas	3,682,506	3,795,249	3,796,019	3,941,487	4,321,880	4,057,049	3,861,577	3,930,157	3,904,231	3,905,868	3,858,375
Blueberries	13,402	13,408	12,529	13,398	20,670	24,248	30,932	27,431	29,277	37,351	37,501
Other Berries	14,251	22,423	19,635	16,446	21,886	22,938	24,423	26,711	42,435	54,159	59,074
Strawberries	61,828	58,220	45,365	53,062	87,237	75,098	71,954	98,292	104,229	104,359	133,002
Cherries	5,939	8,158	9,398	8,697	8,599	12,973	14,311	29,354	32,689	22,471	23,325
Grapefruits	35,866	31,012	28,941	24,784	41,767	66,208	46,591	39,522	40,473	108,204	100,250
Oranges	1,292,173	1,918,797	1,741,635	2,048,398	2,491,377	2,203,739	1,687,046	1,364,614	1,978,492	1,682,169	2,475,214
Lemons	129,491	88,125	224,291	323,015	325,539	478,204	364,730	475,840	582,408	530,351	623,082
Coconuts	57,260	62,719	69,442	76,175	72,238	78,465	79,069	77,082	77,039	70,674	76,219
Dates	3,356	4,189	2,685	3,618	5,099	4,761	4,414	4,481	5,272	5,829	5,901
Figs	10,278	4,717	5,145	2,809	4,064	5,248	7,251	7,380	8,738	4,749	6,851
Kiwis	0	39,913	34,417	44,006	44,740	51,832	50,822	42,879	34,871	37,166	41,108
Grapes	901,866	1,199,608	1,357,554	1,192,610	1,306,708	1,378,759	1,346,744	1,653,716	1,697,579	1,711,756	2,070,265
Melons	559,522	466,770	585,508	617,632	705,489	692,872	651,444	683,352	664,421	586,037	615,681
Mangos	157,713	186,511	204,742	220,145	244,345	257,756	261,815	288,968	316,512	319,979	307,715
Olives	77,893	69,399	85,526	94,545	95,563	98,173	119,338	114,374	116,096	118,258	125,570
Palm Hearts	2,384	3,119	2,755	2,775	3,781	4,052	4,651	4,657	5,238	5,101	5,902
Papayas	36,623	60,563	52,109	52,178	70,737	74,177	89,332	93,965	108,132	131,959	122,439
Peaches	60,897	63,245	61,166	49,244	61,005	86,394	97,012	108,192	115,199	125,968	138,745
Pears	49,122	62,555	98,962	73,902	92,721	95,072	94,025	91,102	104,434	89,060	99,031
Pineapples	1,206,520	1,214,975	1,233,566	1,097,914	1,402,787	1,325,341	1,306,079	1,451,836	1,628,947	1,544,071	1,660,128
Plums	24,365	21,779	24,161	21,267	27,848	24,816	34,630	35,344	32,298	36,466	41,486
Watermelons	152,574	206,508	228,706	219,631	218,477	202,283	219,332	204,726	221,918	248,057	299,268
TOTAL	**10,083,875**	**11,340,359**	**11,739,569**	**11,971,943**	**13,711,573**	**13,385,135**	**12,735,363**	**13,203,864**	**14,491,499**	**14,247,315**	**16,172,450**

Appendix 1 table 7: U.S. Fruit 'Land Import' by Commodity (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Apples	113,850	111,090	113,103	116,418	98,862	117,675	113,777	139,325	145,703	161,220	176,919
Apricots	16,333	17,325	13,221	8,583	13,828	10,129	11,200	17,107	10,777	16,175	13,901
Avocados	5,543	6,677	7,374	11,641	12,351	16,554	14,468	20,262	23,135	22,834	35,948
Bananas	114,491	109,616	103,509	118,705	117,546	121,059	115,291	109,505	108,383	107,101	105,653
Blueberries	5,545	5,187	5,570	7,190	7,239	9,871	11,221	9,878	8,735	12,015	11,855
Other Berries	2,366	4,459	3,791	3,372	4,277	4,269	5,574	5,574	8,755	9,726	11,494
Strawberries	3,503	3,690	3,028	3,069	4,667	3,907	3,724	4,860	4,530	4,592	6,257
Cherries	1,105	1,481	1,910	1,760	1,615	2,369	2,757	6,127	6,344	4,409	4,579
Grapefruits	1,498	1,241	1,264	1,195	1,994	3,993	2,343	2,112	2,103	5,044	4,869
Oranges	82,488	112,162	102,462	131,664	144,294	120,461	100,019	81,682	115,599	101,973	145,612
Lemons	7,273	5,288	15,037	22,827	21,724	26,356	18,910	27,147	36,509	33,392	39,023
Coconuts	15,341	17,166	17,982	19,860	19,845	18,603	17,882	16,824	16,456	15,291	16,180
Dates	459	582	434	407	677	657	615	649	901	870	900
Figs	2,851	1,317	1,527	860	1,236	1,654	2,307	2,833	2,877	1,671	2,366
Kiwis	0	2,239	1,963	2,255	2,846	2,991	2,484	2,448	2,072	6,403	2,234
Grapes	89,706	113,850	129,278	117,273	125,705	129,105	134,405	168,047	167,506	159,492	181,605
Melons	35,773	26,384	35,205	36,516	43,882	37,990	31,269	33,788	31,055	28,564	29,626
Mangos	16,010	21,214	21,130	23,633	25,617	27,500	26,519	29,088	33,636	33,102	31,997
Olives	72,027	31,950	35,300	43,942	55,437	44,098	45,211	56,315	41,921	41,291	44,588
Palm Hearts	181	241	220	219	292	314	371	366	412	378	444
Papayas	1,264	2,301	1,971	2,020	2,643	2,347	2,802	2,722	3,355	3,691	3,377
Peaches	4,871	4,985	4,888	4,588	4,703	6,982	7,234	8,338	8,602	9,746	11,210
Pears	2,409	2,793	5,161	3,308	4,207	4,870	4,994	4,625	5,235	4,682	5,157
Pineapples	55,923	49,667	50,441	43,681	60,254	54,354	52,473	58,653	59,272	54,931	64,282
Plums	2,209	1,891	2,080	2,270	2,176	2,133	2,393	2,493	2,035	2,410	2,811
Watermelons	9,425	12,082	12,161	10,281	9,760	8,866	9,900	9,238	9,876	11,021	13,461
TOTAL	**662,445**	**666,876**	**690,011**	**737,538**	**787,676**	**779,107**	**740,143**	**820,008**	**855,783**	**852,026**	**966,348**

Appendix 1 Table 8: U.S. Fruit Imports by Country (fresh equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	598,928	737,181	862,941	645,365	910,675	759,995	955,850	847,609	901,148	682,484	1,049,219
Australia	26,910	41,534	62,812	75,640	84,666	106,606	124,489	184,687	238,652	282,810	314,814
Bahamas	21,837	21,869	21,964	14,101	14,686	12,412	31,099	26,533	27,207	17,012	14,390
Belize	648,428	67,854	129,201	57,535	89,466	158,505	84,164	32,408	70,137	198,323	225,605
Bolivia	4	2	26	0	0	14	26	101	121	186	449
Brazil	694,655	1,404,162	1,115,687	1,306,939	1,865,208	1,420,535	1,074,208	803,363	1,486,405	1,011,155	1,502,567
Canada	118,306	132,930	130,288	104,110	122,663	134,318	143,095	137,593	140,793	137,275	135,236
China	14,432	29,530	121,676	290,251	240,635	295,487	336,179	563,335	1,035,836	1,388,930	1,503,359
Chile	545,788	729,229	713,908	712,258	911,946	884,877	967,083	1,044,177	1,182,723	1,107,672	1,224,663
Colombia	442,924	383,593	466,662	416,654	607,131	605,264	475,715	510,934	478,043	470,684	523,791
Costa-Rica	1,186,142	1,214,260	1,370,794	1,624,269	2,100,392	2,086,948	1,737,774	1,627,458	1,810,535	1,673,193	1,637,649
Dominican Republic	54,317	84,474	85,733	72,239	84,092	73,642	80,503	80,674	78,655	54,904	59,620
Ecuador	942,847	868,493	886,552	1,094,225	1,200,136	1,010,796	984,281	1,072,030	1,047,901	992,790	980,733
El-Salvador	4,992	3,622	2,705	1,222	310	680	582	676	756	754	404
Guatemala	534,773	582,742	565,267	768,399	651,401	883,726	999,852	1,156,995	1,177,644	1,258,069	1,285,693
Haiti	10,019	8,247	10,374	7,150	9,164	10,175	5,877	8,441	6,208	8,091	9,396
Honduras	739,882	802,018	760,811	549,071	240,103	453,792	555,948	621,821	624,662	710,781	667,453
India	3,308	3,594	2,645	3,439	3,555	7,281	3,919	3,932	5,237	5,574	4,412
Indonesia	74,624	139,624	172,971	119,509	178,067	156,515	142,589	173,690	149,014	131,160	154,284
Israel	8,426	8,657	8,840	7,183	8,572	7,420	5,221	5,038	6,341	8,314	7,738
Italy	160,292	216,763	296,418	334,345	361,869	457,503	399,181	361,882	343,625	305,034	333,120
Jamaica	12,051	10,405	2,536	2,883	2,876	5,563	2,608	2,383	1,998	1,059	1,089
Mexico	1,480,608	1,327,676	1,565,751	1,854,009	1,788,130	1,564,121	1,391,804	1,463,387	1,337,758	1,515,185	2,033,119
Nicaragua	9,219	9,411	10,183	4,535	3,136	5,736	4,287	4,956	4,858	5,855	10,460

Table 8 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
New-Zealand	55,142	72,331	126,609	74,091	92,929	140,481	131,970	97,816	80,024	108,071	63,861
Pakistan	2,118	3,138	3,323	3,770	7,491	5,639	2,589	2,417	3,614	2,889	2,579
Panama	146,719	276,573	232,865	30,803	146,887	38,298	21,723	11,538	12,623	13,069	16,330
Peru	5,229	5,692	5,013	3,837	12,374	14,126	23,598	49,573	39,574	51,009	63,569
Philippines	546,321	500,818	512,759	466,738	479,855	518,237	536,530	529,676	610,594	541,786	516,438
South-Africa	54,439	42,922	54,186	59,184	57,179	68,259	64,254	92,221	99,520	58,908	67,925
Spain	78,747	83,998	119,305	122,117	148,998	121,922	126,852	144,414	131,513	129,146	136,587
Sri-Lanka	422	510	322	462	427	378	434	454	591	512	929
Thailand	382,571	353,065	298,109	222,324	415,952	315,033	302,395	303,702	335,698	336,783	366,835
Turkey	124,628	153,594	91,890	99,747	132,963	152,863	163,007	132,543	97,559	122,815	96,196
Venezuela	7,625	9,071	6,356	5,531	4,304	4,752	4,309	4,372	2,250	2,087	1,128
Vietnam	318	4,297	6,139	5,628	9,302	1,892	2,738	4,048	5,109	8,465	4,357
Others	337,005	997,266	905,667	803,319	711,510	892,150	843,735	1,092,370	910,914	898,179	1,149,607

Appendix 1 table 9: U.S. Fruit ‘Imported Land’ by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	26,928	44,336	44,272	33,597	44,357	39,969	41,480	45,515	44,098	38,479	56,336
Australia	2,045	2,586	4,179	4,961	6,066	8,243	9,790	14,499	21,643	20,734	22,940
Bahamas	943	1,025	1,057	737	777	677	1,778	1,713	1,533	965	775
Belize	67,443	6,914	13,560	7,374	12,432	13,683	6,183	1,937	4,574	10,299	11,961
Bolivia	1	0	5	0	0	2	5	16	11	17	34
Brazil	32,754	67,866	51,615	66,365	86,841	62,895	53,992	39,064	75,104	47,277	85,226
Canada	12,078	13,320	12,945	13,734	12,765	16,193	18,696	16,863	16,605	17,693	16,919
China	1,043	1,624	1,959	1,780	1,984	2,076	3,050	4,053	8,086	9,523	11,505
Chile	35,237	42,977	43,928	49,085	53,188	62,132	63,710	78,283	76,625	74,339	78,693
Colombia	15,098	13,201	15,133	13,646	19,669	19,995	16,670	18,459	18,205	19,286	20,990
Costa-Rica	33,444	34,118	38,634	42,455	51,633	57,042	44,011	42,431	48,135	53,807	44,574
Dominican Republic	9,017	11,162	11,865	9,281	10,229	9,452	10,051	9,676	9,189	6,825	8,105
Ecuador	40,348	35,083	25,738	42,244	38,023	42,289	39,836	42,243	43,161	39,515	39,329
El-Salvador	480	354	271	123	33	73	63	73	82	38	21
Greece	2,557	3,015	2,964	3,809	4,204	4,337	4,805	4,853	6,422	4,934	5,666
Guatemala	17,660	18,347	17,671	24,363	17,720	21,368	22,913	24,976	26,243	27,092	27,955
Haiti	1,457	1,257	1,581	1,017	1,303	1,302	752	1,068	797	1,058	1,229
Honduras	25,959	25,761	26,585	20,978	14,363	26,072	27,046	20,659	20,378	22,244	21,507
India	330	386	353	448	484	582	532	576	686	689	649
Indonesia	6270	11644	18275	14626	22488	19255	17941	20325	14313	12019	18345
Israel	295	360	651	473	674	465	479	351	890	435	487
Italy	17,232	18,754	27,500	24,612	24,966	29,914	29,404	36,007	36,381	28,633	28,241
Jamaica	1,142	952	170	197	226	506	185	150	146	53	53
Mexico	110,165	95,900	107,800	141,103	132,148	118,831	101,096	108,762	99,267	107,181	150,378
Nicaragua	610	579	606	332	223	402	322	371	410	375	603

Table 9 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
New Zealand	1,643	2,403	3,471	2,635	3,305	4,996	5,076	3,826	4,062	8,691	4,512
Pakistan	287	433	430	403	1,314	950	350	346	634	408	359
Panama	4,051	6,849	9,695	2,599	8,026	3,774	1,755	3,051	3,661	3,393	3,568
Peru	341	535	458	329	735	1,306	1,840	3,391	2,475	2,907	3,593
Philippines	33,148	22,906	21,183	23,093	23,709	23,109	22,739	22,885	25,329	22,519	21,974
South-Africa	3,940	3,942	5,628	4,611	6,964	9,074	8,733	12,241	16,062	9,506	9,497
Spain	67,742	29,240	30,719	41,132	51,421	39,372	35,328	51,150	33,447	31,961	33,787
Sri- Lanka	89	117	71	107	88	68	85	108	129	113	176
Thailand	17,312	15,854	13,847	13,000	19,743	16,152	16,626	16,473	17,175	17,825	19,415
Turkey	20,582	21,719	16,451	10,131	17,911	13,402	17,713	19,705	13,820	18,953	17,158
Venezuela	531	639	442	373	308	398	253	285	141	151	72
Vietnam	44	606	795	666	1,312	234	361	448	642	668	357

Appendix 1 table 10: U.S. Apple Imports (metric tons/year) and Imported Land (hectares) from Specific Countries

		1995	1996	1997	1998	1999	2000		1995	1996	1997	1998	1999	2000
Argentina	Mt	434,323	446,595	518,331	405,817	576,847	321,019	Ha	18,192	18,758	20,545	17,798	23,260	17,720
Australia	Mt	135	1,366	1,872	0	43	269	Ha	8	96	105	0	3	17
Brazil	Mt	25,094	38,503	44,238	20,554	31,639	84,740	Ha	976	1,392	1,473	683	963	2,208
Canada	Mt	91,565	105,785	104,334	74,202	82,837	85,931	Ha	4,796	6,054	5,782	4,088	3,477	4,002
China	Mt	15,285	32,023	120,147	272,888	215,991	278,788	Ha	3,221	5,608	19,802	36,718	25,324	30,758
Chile	Mt	125,523	197,421	194,085	217,129	398,747	273,884	Ha	4,791	7,232	9,165	8,552	12,692	12,177
India	Mt	605	610	0	0	0	2,960	Ha	106	103	0	0	0	648
Italy	Mt	159	35,567	68,484	120,035	138,995	211,930	Ha	6	1,229	2,266	3,599	3,775	5,937
Mexico	Mt	24,465	14,613	33,131	30,741	34,152	58,698	Ha	3,632	2,060	3,291	4,877	4,895	9,503
New Zealand	Mt	48,113	68,861	107,952	56,716	69,150	110,955	Ha	1,453	1,984	3,008	1,627	1,840	2,526
South Africa	Mt	52,009	63,679	81,958	54,496	112,857	105,489	Ha	2,107	2,407	3,216	2,045	4,380	4,377
Spain	Mt	2,215	3,513	2,458	935	9,171	4,968	Ha	140	193	124	63	456	298
Turkey	Mt	34,747	76,962	23,955	22,655	42,819	59,940	Ha	1,794	3,747	1,006	984	1,830	2,687
Other Countries	Mt	578,143	537,808	406,050	346,187	164,653	271,756	Ha	72,628	60,224	43,319	35,378	15,957	24,805

Table 10 (continued)

		2001	2002	2003	2004	2005		2001	2002	2003	2004	2005
Argentina	Mt	538,454	373,748	473,735	283,397	463,235	Ha	18,089	16,154	18,117	8,979	14,677
Australia	Mt	518	1,440	0	131	0	Ha	40	140	0	15	0
Brazil	Mt	16,984	48,907	18,937	24,937	375,995	Ha	734	1,798	709	842	15,739
Canada	Mt	86,537	92,077	91,695	80,718	82,744	Ha	4,369	4,963	5,223	4,536	4,650
China	Mt	317,427	530,350	969,461	1,306,137	1,396,294	Ha	32,768	53,421	87,328	115,858	122,876
Chile	Mt	388,324	349,099	482,009	461,502	386,977	Ha	12,214	10,584	13,654	12,814	10,463
India	Mt	362	0	269	677	0	Ha	71	0	46	115	0
Italy	Mt	141,032	67,173	31,658	12,572	9,445	Ha	3,794	2,789	1,454	363	265
Mexico	Mt	35,814	43,230	38,260	28,050	17,853	Ha	4,935	5,857	4,861	3,457	2,201
New Zealand	Mt	114,156	79,820	63,821	90,569	60,096	Ha	3,112	1,762	1,519	2,147	1,322
South Africa	Mt	66,426	62,492	97,152	63,963	8,598	Ha	2,834	2,584	3,264	2,169	235
Spain	Mt	275	840	1,217	781	594	Ha	13	52	64	41	31
Turkey	Mt	68,507	36,872	10,508	30,688	11,460	Ha	3,031	1,842	471	1,591	524
Other Countries	Mt	307,222	420,504	108,773	108,462	48,254	Ha	27,768	37,365	8,989	8,286	3,931

Appendix 1 table 11: U.S. Banana Imports (metric tons/year) and Imported Land (hectares) from Specific Countries

		1995	1996	1997	1998	1999	2000		1995	1996	1997	1998	1999	2000
Colombia	Mt	439,564	381,592	466,140	415,199	606,153	603,945	Ha	14,852	13,071	15,088	13,518	19,568	19,844
Costa Rica	Mt	964,359	975,349	961,056	1,104,265	1,618,706	1,374,392	Ha	21,872	21,133	20,554	20,746	32,661	29,369
Dominican Republic	Mt	719	2,058	8,820	6,387	11,750	6,437	Ha	58	161	680	516	952	525
Ecuador	Mt	934,626	853,366	877,810	1,082,926	1,175,718	981,103	Ha	39,422	33,667	24,742	41,016	35,610	38,258
Guatemala	Mt	463,358	505,157	462,682	654,626	501,946	688,467	Ha	13,802	14,836	13,310	18,597	11,991	15,097
Honduras	Mt	585,578	642,925	568,754	383,139	87,125	277,206	Ha	15,127	14,197	13,437	9,963	4,320	13,270
Jamaica	Mt	78	75	38	60	56	48	Ha	10	9	5	8	7	6
Mexico	Mt	155,710	141,917	202,806	220,741	140,889	85,390	Ha	5,636	4,394	8,020	9,612	6,111	3,297
Panama	Mt	126,965	263,284	214,776	5,391	130,973	28,707	Ha	2,791	5,968	5,387	168	3,207	562
Peru	Mt	0	0	0	0	0	302	Ha	0	0	0	0	0	19
Philippines	Mt	4,726	4,132	5,413	4,849	4,735	4,750	Ha	435	408	485	455	386	317
Thailand	Mt	320	296	233	304	343	325	Ha	25	23	18	24	27	25
Venezuela	Mt	4,606	5,755	5,438	4,519	3,471	3,852	Ha	330	419	382	307	256	337
Other countries	Mt	1,898	19,343	22,053	59,081	40,014	2,126	Ha	132	1,331	1,402	3,774	2,449	134

Table 11 (continued)

		2001	2002	2003	2004	2005		2001	2002	2003	2004	2005
Colombia	Mt	474,251	506,777	469,996	465,562	515,802	Ha	16,475	17,958	17,360	18,575	19,987
Costa Rica	Mt	1,088,865	909,671	985,909	878,637	836,660	Ha	22,709	18,718	20,319	18,087	17,223
Dominican Republic	Mt	7,374	3,587	2,140	5,209	4,435	Ha	601	271	167	412	355
Ecuador	Mt	951,669	1,027,514	977,308	925,627	910,765	Ha	35,859	38,214	36,331	33,191	32,389
Guatemala	Mt	832,261	925,461	934,358	1,021,208	1,029,547	Ha	17,516	17,621	18,531	19,444	19,603
Honduras	Mt	383,229	450,726	434,037	509,501	454,912	Ha	16,685	11,313	10,316	12,062	10,530
Jamaica	Mt	61	50	143	29	0	Ha	8	6	18	4	0
Mexico	Mt	64,026	42,692	35,391	33,704	33,913	Ha	2,243	1,424	1,269	1,208	1,216
Panama	Mt	16,187	259	232	612	2,019	Ha	419	6	5	14	46
Peru	Mt	5,743	23,196	13,756	12,431	22,530	Ha	338	1,374	796	710	1,266
Philippines	Mt	5,720	6,082	6,812	8,446	8,043	Ha	437	459	520	622	596
Thailand	Mt	545	608	337	899	548	Ha	42	47	26	69	42
Venezuela	Mt	3,283	3,684	1,930	2,008	670	Ha	184	231	117	145	44
Other countries	Mt	28,362	29,852	41,883	41,997	38,532	Ha	1,775	1,862	2,608	2,558	2,358

Appendix 1 table 12: U.S. Grain Imports by Commodity (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	2,117,586	1,887,044	2,804,111	2,668,676	2,859,589	2,523,401	2,791,997	2,711,052	1,672,680	1,860,744	2,071,859
Oats	1,552,842	1,394,443	1,968,148	1,815,687	1,766,615	1,821,077	2,097,140	1,587,918	1,717,912	1,574,457	1,852,289
Maize	468,548	554,936	486,120	517,390	669,190	508,646	450,960	584,251	685,040	741,256	513,903
Rice	340,286	415,176	472,059	446,547	532,855	457,899	614,772	625,371	682,608	703,260	621,656
Millet	958	990	1,253	411	669	465	1,056	2,841	3,205	2,092	1,566
Barley	1,098,110	855,526	926,161	775,643	707,319	720,032	783,678	671,172	507,060	645,017	297,646
Rye	107,181	94,647	144,316	94,281	82,446	83,598	132,106	128,968	93,935	161,865	124,700
TOTAL	**5,685,511**	**5,202,763**	**6,802,169**	**6,318,636**	**6,618,682**	**6,115,118**	**6,871,708**	**6,311,571**	**5,362,439**	**5,688,692**	**5,483,619**

Appendix 1 table 13: U.S. Grain 'Imported Land' by Commodity (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	931,383	777,699	1,288,463	1,166,988	1,104,976	1,093,398	1,468,135	1,471,292	803,986	760,600	853,052
Oats	683,407	549,340	866,735	795,765	752,900	723,425	976,340	762,374	749,416	590,638	778,406
Maize	80,671	95,184	87,504	84,300	106,130	95,682	86,041	100,459	114,094	133,924	97,231
Rice	137,232	161,106	182,857	169,445	189,746	169,811	206,961	208,614	223,474	243,593	225,839
Millet	860	878	985	468	790	363	666	1,656	1,197	1,126	1,445
Barley	369,289	269,591	321,739	263,439	217,408	240,129	299,673	300,542	188,588	196,784	92,662
Rye	56,082	49,463	71,036	47,745	35,977	36,777	64,865	64,132	42,671	63,736	53,034
TOTAL	**2,258,924**	**1,903,260**	**2,819,319**	**2,528,150**	**2,407,928**	**2,359,584**	**3,102,681**	**2,909,068**	**2,123,427**	**1,990,402**	**2,101,670**

Appendix 1 table 14: U.S. Grain Imports by Country (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	2,248	8,718	47,734	26,178	30,504	21,749	14,869	18,598	39,840	59,392	13,740
Australia	576	1,899	2,231	2,913	61,055	2,089	76,044	92,623	2,488	3,766	4,069
Bangladesh	48	20	133	99	225	247	170	289	173	240	292
Bolivia	0	4	4	0	0	0	2	0	0	16	6
Brazil	81	531	1,244	2,018	451	179	626	1,098	2,471	1,481	3,785
Canada	4,710,658	4,251,199	5,394,073	4,622,007	5,026,961	4,896,958	5,055,645	4,301,614	3,328,251	3,947,226	3,942,479
Chile	14,647	23,806	24,464	35,290	40,980	38,302	39,296	40,325	46,179	37,611	35,227
China	24,778	23,834	20,018	22,935	77,666	28,371	27,155	32,532	157,355	117,821	45,884
Colombia	55	48	62	83	58	760	1,376	1,639	2,303	2,380	1,983
Costa Rica	17	8	0	6	0	0	2	14	25	43	75
Dominican Republic	833	726	14	55	169	704	303	487	756	1,522	1,530
Ecuador	4	9	11	8	16	34	99	113	97	195	143
El Salvador	70	68	138	116	104	137	312	979	829	1,079	1,711
Ethiopia	0	0	0	0	1	0	0	1	2	4	3
Greece	2,012	2,603	4,426	5,798	3,791	3,101	2,424	3,490	3,575	2,525	2,745
Guatemala	0	0	22	2	7	52	0	19	75	181	196
Honduras	0	0	223	26	0	39	34	42	9	27	45
India	27,553	41,691	38,359	48,613	52,616	64,192	68,252	77,790	75,197	80,563	93,512
Indonesia	521	71	94	66	7	112	156	295	159	3	15
Israel	233	303	199	210	266	311	335	614	612	795	954
Italy	8,727	8,622	9,393	11,354	13,837	214,472	234,272	232,076	225,946	206,112	236,246
Jamaica	2	3	8	0	0	0	2	21	12	8	33
Malaysia	70	39	0	10	1	12	26	29	21	32	57
Mexico	53,416	74,750	79,448	110,013	112,924	110,283	139,603	116,902	157,326	206,215	197,841
Nicaragua	0	0	0	0	0	2	2	1	2	2	0

Table 14 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pakistan	9,611	6,933	8,807	13,236	11,819	16,418	14,172	15,447	17,560	23,446	21,408
Peru	684	1,101	228	170	392	376	628	962	1,182	1,736	1,407
Philippines	123	385	280	241	169	162	367	722	580	586	597
South Africa	20	0	0	0	20	20	0	20	0	0	40
Spain	1,322	1,004	605	596	757	2,392	652	1,656	2,376	853	353
Thailand	312,135	323,946	358,224	342,278	368,656	372,343	456,710	436,473	473,545	532,113	509,447
Turkey	13,688	15,335	15,998	16,833	16,819	18,138	2,899	4,534	4,911	2,996	6,019
Venezuela	1,061	2,959	3,111	3,116	3,038	3,876	3,032	2,418	3,452	2,186	3,526
Vietnam	475	28,387	45,872	26,750	1,040	1,180	1,378	1,403	1,138	673	860

Appendix 1 table 15: U.S. Grain ‘Imported Land’ by country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	497	2,161	10,477	4,309	5,693	4,013	3,356	3,459	12,527	18,182	2,459
Australia	212	470	699	924	29,845	819	8,905	12,031	854	1,405	1,576
Bangladesh	18	7	49	34	74	71	50	90	51	67	86
Bolivia	0	2	2	0	0	0	1	0	0	7	3
Brazil	35	198	479	725	164	69	207	384	683	431	1,228
Canada	1,833,358	1,519,604	2,246,271	1,805,066	1,750,214	1,816,426	2,303,430	2,039,210	1,267,273	1,303,416	1,418,972
China	6,794	6,260	4,805	6,130	14,405	7,423	7,014	8,436	28,940	21,572	10,595
Chile	1,610	2,520	2,968	3,754	4,812	4,069	4,167	3,808	4,621	3,398	3,137
Colombia	35	29	36	50	32	361	663	775	1,082	1,032	834
Costa Rica	9	5	0	3	0	0	1	8	12	30	52
Dominican Republic	663	563	12	46	133	683	227	376	515	1,090	1,147
Ecuador	3	8	9	9	14	33	136	97	79	134	97
El Salvador	31	30	83	61	41	61	159	311	296	345	556
Ethiopia	0	0	39	0	13	45	66	105	81	104	64
Greece	764	1,079	1,831	2,378	1,506	990	869	1,299	1,604	989	1,117
Guatemala	0	0	15	1	4	29	0	11	43	102	110
Honduras	0	0	143	24	0	27	23	31	6	193	29
India	10,229	14,779	13,500	16,903	17,698	22,596	22,029	27,158	24,705	26,942	31,571
Indonesia	231	29	36	25	3	33	51	96	41	1	4
Israel	25	26	14	14	19	25	28	47	38	50	60
Italy	2,180	1,896	2,195	2,378	3,216	65,876	81,313	73,260	80,882	55,339	64,146
Jamaica	1	2	7	0	0	0	2	18	10	7	29
Malaysia	37	20	0	6	0	5	8	9	7	10	18
Mexico	20,672	26,067	25,329	36,412	36,512	33,756	40,561	33,437	48,015	66,284	65,033
Nicaragua	0	0	0	0	0	1	2	1	1	2	0

Table 15 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pakistan	3,492	2,417	3,140	4,575	3,844	5,417	5,155	5,129	5,956	7,865	7,291
Peru	360	552	116	84	175	158	251	397	449	675	512
Philippines	80	177	176	135	97	90	187	351	288	258	276
South Africa	32	0	0	0	36	35	0	35	0	0	70
Spain	874	326	235	188	332	741	185	282	283	126	62
Thailand	127,133	133,625	149,943	138,358	151,395	141,482	172,440	165,547	175,590	200,983	190,185
Turkey	7,141	7,742	8,005	7,525	8,753	8,105	1,407	2,135	2,334	1,294	2,630
Venezuela	307	460	443	541	485	600	807	742	1,006	624	1,032
Vietnam	218	7,648	12,020	6,822	410	402	459	416	321	163	221

Appendix 1 table 16: U.S. Legume Imports by Commodity (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Beans	88,363	80,062	96,577	104,492	130,798	159,550	210,397	271,096	258,959	292,917	276,594
Chickpeas	11,552	15,027	16,496	13,261	14,759	15,066	14,736	16,135	16,207	19,455	17,342
Lentils	5,298	8,108	15,107	14,149	8,643	7,998	10,053	11,562	13,775	16,855	14,244
Peas	73,995	73,161	83,621	80,800	84,097	79,933	82,495	94,136	112,786	122,499	125,425
TOTAL	**179,206**	**176,358**	**211,800**	**212,701**	**238,297**	**262,548**	**317,681**	**392,929**	**401,727**	**451,726**	**433,605**

Appendix 1 table 17: U.S. Legume 'Imported land' by Commodity (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Beans	53,224	42,158	52,310	52,582	69,509	94,340	117,916	164,192	145,952	190,443	179,675
Chickpeas	8,446	10,987	11,740	10,477	11,463	10,875	12,204	14,068	13,956	15,364	13,599
Lentils	5,284	7,635	14,676	13,001	8,004	8,321	12,913	14,890	16,098	15,980	13,598
Peas	30,921	26,730	33,144	30,515	27,627	29,935	35,646	41,436	39,727	40,136	44,848
TOTAL	**97,875**	**87,510**	**111,870**	**106,576**	**116,603**	**143,471**	**178,679**	**234,586**	**215,732**	**261,923**	**251,721**

Table 18: U.S. Legume Imports by Country (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	18	20	83	169	58	187	275	7,417	441	285	751
Australia	1,717	2,634	2,670	2,154	2,148	4,013	3,779	2,776	1,819	1,611	1,299
Bangladesh	0	0	0	0	0	0	0	0	0	10	32
Belize	0	0	0	0	0	0	205	100	952	90	248
Bolivia	0	0	0	17	0	295	87	255	219	13	67
Brazil	0	0	9	1	0	10	29	1,953	223	236	264
Canada	87,290	88,308	110,703	113,581	122,353	130,608	175,616	195,453	201,775	221,328	198,544
China	8,444	6,921	6,240	7,004	13,860	17,165	23,918	32,824	24,397	31,355	35,452
Chile	224	417	145	67	301	173	596	2,477	1,064	982	1,961
Colombia	43	35	140	135	22	91	60	256	490	288	243
Costa Rica	12	0	0	0	104	183	120	163	39	3	167
Dominican Republic	4,220	1,613	3,770	4,185	2,690	2,061	4,536	4,569	4,100	4,030	5,419
Ecuador	1,963	2,335	2,126	593	2,809	4,673	4,372	5,506	5,211	5,657	4,422
El Salvador	2,279	1,512	1,723	1,935	1,867	1,898	3,871	3,580	3,321	2,695	3,342
Ethiopia	0	0	0	0	0	265	520	832	201	1,229	626
Greece	0	0	0	0	0	0	0	3	5	0	1
Guatemala	14,208	8,284	9,018	10,813	10,169	14,906	14,931	14,984	20,060	24,387	25,151
Honduras	21	3	28	0	16	0	4	272	500	134	334
India	4,637	4,884	6,746	7,186	7,859	10,337	11,594	14,095	13,242	13,925	13,865
Israel	16	70	36	0	12	27	17	6	69	87	208
Italy	1,579	1,217	1,636	1,379	2,137	2,673	2,575	2,227	2,824	2,563	3,471
Malaysia	155	177	292	264	347	437	463	502	517	599	627
Mexico	41,515	46,942	51,448	48,534	51,839	47,598	49,268	62,655	60,173	64,445	67,713
Nicaragua	32	40	310	0	153	388	145	594	1,545	1,839	3,387
New Zealand	351	285	582	379	676	654	1,073	1,019	6,652	7,847	5,452
Pakistan	21	0	0	0	0	13	32	69	21	30	240
Peru	1,847	1,639	1,293	2,766	4,347	3,563	6,881	7,902	6,763	9,377	13,551

Table 18 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Spain	24	2	12	70	101	228	224	277	728	180	249
Thailand	565	658	700	548	798	2,757	3,165	3,634	3,992	4,287	4,383
Turkey	961	2,164	2,223	1,582	1,739	1,533	1,520	1,871	1,919	2,274	2,406
Vietnam	0	6	0	0	20	20	0	4	8	7	11

Appendix 1 table 19: U.S. Legume 'Imported land' by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	17	22	79	150	55	174	269	6,848	379	406	637
Australia	1,384	2,077	3,240	2,718	2,025	4,592	3,041	3,800	1,609	1,624	981
Bangladesh	0	0	0	0	0	0	0	0	0	13	40
Belize	0	0	0	0	0	0	245	47	447	16	174
Bolivia	0	0	0	17	0	296	86	253	182	12	61
Brazil	0	0	14	2	0	14	42	2,637	278	308	327
Canada	41,367	40,496	51,904	47,906	47,576	60,168	94,604	102,901	91,554	101,692	88,202
China	3,742	2,601	2,571	2,928	4,535	8,437	13,857	18,028	9,502	9,910	11,487
Chile	156	247	91	36	168	56	267	1,409	352	480	1,629
Colombia	43	36	135	135	16	85	47	207	390	224	204
Costa Rica	20	0	0	0	216	347	181	284	54	5	271
Dominican Republic	1,087	406	902	1,020	665	510	874	1,032	885	879	1,143
Ecuador	1,866	1,713	2,331	385	2,746	6,679	6,199	4,072	4,199	5,174	4,195
El Salvador	1,764	1,238	1,680	2,447	1,928	1,754	3,530	2,912	2,659	2,221	3,165
Ethiopia	0	0	0	0	0	0	0	1,561	6	1,691	862
Greece	0	0	0	0	0	0	0	2	4	0	1
Guatemala	4,275	2,333	2,341	3,089	2,119	3,164	3,258	3,220	4,286	5,211	5,302
Honduras	37	5	31	0	33	0	5	432	730	176	455
India	6,606	8,001	10,229	11,204	10,431	15,673	18,663	21,287	21,530	20,770	25,194
Israel	15	43	21	0	7	13	8	5	50	67	129
Italy	710	590	683	559	858	1,232	954	846	1,097	1,061	1,650
Malaysia	47	6	209	609	245	49	99	96	23	23	961
Mexico	23,451	16,055	20,398	18,549	23,018	17,443	15,898	27,087	27,219	36,381	39,865
Nicaragua	50	64	583	0	235	498	189	714	1,939	2,420	3,866

Table 19 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
New Zealand	115	92	185	135	238	210	370	496	2,049	2,493	1,788
Pakistan	39	0	0	0	0	20	54	117	35	50	410
Peru	1,573	1,574	1,366	1,538	2,417	2,334	5,368	4,882	4,039	6,164	7,365
Spain	7	2	15	6	23	38	59	87	214	119	286
Thailand	674	752	827	615	847	3,322	3,787	4,409	4,451	4,380	4,254
Turkey	938	2,155	2,251	1,550	2,009	1,872	1,572	1,696	1,687	2,082	2,265
Vietnam	0	9	0	0	28	29	0	6	10	10	14

Appendix 1 table 20: U.S. Oil Crop Imports by Commodity (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Flaxseed & Linseed	191,250	210,072	232,460	183,344	198,589	139,456	62,471	77,407	120,285	116,915	168,087
Ground nuts	167,242	188,808	232,403	416,143	276,596	379,238	501,638	487,229	194,999	565,797	281,966
Mustard seeds	77,238	91,796	82,146	79,643	72,831	79,305	84,708	79,009	81,734	84,719	90,924
Olives	799,106	731,889	1,048,927	1,044,579	996,471	1,282,810	1,355,600	1,419,693	1,363,779	1,564,731	1,636,618
Palm	4,980,451	6,081,025	6,603,020	6,054,977	8,327,825	6,980,327	6,384,792	7,375,460	9,176,235	10,418,924	10,593,663
Rapeseeds	994,082	1,186,280	1,103,585	1,110,276	1,222,180	1,236,297	1,239,518	908,947	1,009,388	1,236,999	1,304,807
Safflower seeds	36,604	38,146	33,737	59,156	52,243	38,424	44,760	36,965	39,165	40,646	69,396
Sesame seeds	55,587	63,037	59,115	63,509	60,287	68,921	69,295	70,574	60,194	67,966	71,171
Soya	233,606	434,421	490,620	389,153	404,939	402,118	342,410	270,122	345,073	1,146,043	331,762
Sunflower seeds	76,877	60,195	83,286	100,945	89,565	94,399	124,729	156,356	202,728	147,767	195,668
TOTAL	**7,612,041**	**9,085,669**	**9,969,300**	**9,501,725**	**11,701,527**	**10,701,295**	**10,209,920**	**10,881,761**	**12,593,579**	**15,390,507**	**14,744,062**

Appendix 1 table 21: U.S. Oil Crop 'Imported Land' by Commodity (hectares / year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Flaxseed & Linseed	148,919	142,239	191,566	145,712	150,325	118,924	57,922	72,502	117,228	121,745	137,041
Ground nuts	94,065	90,383	164,376	197,064	181,247	165,795	247,168	234,560	108,781	437,833	150,009
Mustard seeds	88,193	98,602	101,375	94,453	68,062	85,499	127,323	127,482	118,653	86,745	92,667
Olives	425,829	358,344	411,212	464,411	427,055	529,302	564,252	571,281	502,237	468,909	551,931
Palm	282,957	336,116	364,160	338,288	459,027	382,825	364,630	445,712	492,572	556,467	544,472
Rapeseeds	814,135	809,233	840,172	788,629	772,957	833,657	935,001	706,706	698,911	790,182	796,305
Safflower seeds	31,543	26,659	20,302	42,660	33,756	33,856	45,572	38,550	18,089	17,743	28,190
Sesame seeds	111,139	127,754	125,890	130,832	126,643	159,054	133,551	153,840	123,565	148,424	149,706
Soya	85,379	174,489	203,654	140,977	148,063	159,402	216,693	117,910	160,681	507,742	143,005
Sunflower seeds	48,160	58,285	67,132	104,612	78,924	84,988	110,430	120,009	173,854	162,447	185,421
TOTAL	**2,130,318**	**2,222,104**	**2,489,839**	**2,447,636**	**2,446,058**	**2,553,302**	**2,802,540**	**2,588,551**	**2,514,572**	**3,298,238**	**2,778,748**

Appendix 1 table 22: U.S. Oil Crop Imports by Country (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	86,820	107,230	177,432	332,549	188,656	280,065	278,236	373,347	144,133	425,028	228,740
Australia	494	1,651	1,311	0	10	835	5,316	6,933	5,687	477	4,090
Bolivia	0	0	0	0	0	126	0	0	0	80,064	950
Brazil	912	260	195,066	336	137	1,700	4,041	1,695	2,433	540,165	56,747
Cameroon	0	60	0	73	59	0	53	320	8	0	0
Canada	1,511,753	1,881,891	1,681,702	1,754,486	1,890,953	1,867,319	1,752,674	1,360,933	1,579,009	1,641,755	1,738,533
China	6,539	12,937	10,895	9,591	15,565	24,233	44,547	33,429	47,849	65,497	98,883
Chile	1,037	1,635	574	532	1,584	4,465	544	265	713	657	961
Colombia	6,680	563	20	0	174	3,468	1,992	4,986	16,720	19,577	15,505
Dominican Republic	14	5	0	0	0	0	0	501	0	0	0
Ecuador	0	0	0	0	0	0	0	10	0	0	1,293
Egypt	0	0	0	0	0	2	1	192	0	16	135
El-Salvador	1,794	1,366	806	1,024	1,140	1,072	1,346	1,368	510	578	457
Ethiopia	0	0	0	3,319	3,268	4,977	4,560	3,884	2,178	1,809	317
Ghana	1,612	1,446	767	1,100	2,007	3,720	6,545	9,634	9,459	10,867	10,036
Greece	26,110	22,488	30,255	28,050	19,191	28,558	27,749	27,831	29,051	21,366	24,110
Guatemala	19,686	17,681	16,113	14,540	12,873	12,414	10,038	12,738	11,460	6,565	9,619
Honduras	443	141	0	85	21	18	0	20	0	0	20
India	5,836	8,184	5,833	10,502	10,815	14,350	17,142	18,246	22,065	377,330	18,311
Indonesia	1,139,210	2,391,424	2,062,584	1,103,416	2,513,182	1,905,208	453,049	325,422	537,127	1,377,037	1,987,583
Ivory Coast	381	1,767	480	521	339	620	1,137	452	141	237	141
Israel	331	3,442	529	595	310	704	534	531	996	1,893	3,427
Italy	567,199	532,297	773,054	762,318	688,613	979,229	974,164	1,020,218	930,144	1,015,854	1,055,432
Malaysia	3,513,459	3,592,423	4,444,254	4,695,655	5,668,102	5,005,481	5,629,420	6,035,850	7,236,417	7,472,003	7,759,668
Mexico	95,798	93,684	85,444	143,516	128,671	104,714	165,655	107,220	116,475	121,057	190,804
Nicaragua	16,588	19,196	18,718	29,530	20,802	11,483	57,128	41,706	18,355	37,829	23,117

Table 22 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Nigeria	284	1,133	317	316	1,457	32	460	633	383	164	102
New Zealand	1	0	0	0	0	71	5	2	0	40	78
Pakistan	152	0	0	0	0	0	18	0	7	0	0
Paraguay	0	0	380	0	0	0	19	22	79	990	1,362
Peru	0	23	36	13	45	27	79	54	136	250	192
Philippines	21,192	28,319	97	90,023	74,645	49,389	125,458	43,450	163,611	18,883	5,239
South Africa	0	1,412	9,582	5,768	3,034	8,189	8,987	3,774	24	12	0
Spain	93,719	90,431	122,574	144,878	147,664	188,495	196,534	284,038	259,028	277,982	291,730
Thailand	898	941	722	1,376	1,251	988	816	1,082	1,411	1,670	1,322
Turkey	85,549	44,722	81,907	64,001	102,273	35,667	101,339	43,117	86,436	66,035	117,132
Venezuela	174	2,875	4,146	4,418	5,194	7,766	6,133	4,305	2,375	8,290	10,348
Vietnam	0	0	33	0	61	31	62	12	43	652	564

Appendix 1 table 23: U.S. Oil Crop ‘Imported Land’ by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	39,466	38,809	125,221	142,201	122,797	103,528	122,867	161,161	74,437	189,398	96,003
Australia	618	2,332	1,794	0	16	561	6,021	8,754	5,627	288	2,332
Bolivia	0	0	0	0	0	148	0	0	0	42,669	506
Brazil	91	26	84,894	45	52	623	1,262	610	342	232,443	22,971
Cameroon	0	3	0	4	3	0	3	16	0	0	0
Canada	1,139,388	1,194,740	1,230,487	1,162,549	1,133,945	1,196,857	1,349,104	1,035,685	1,112,201	1,100,092	1,082,957
China	2,920	8,102	6,241	4,589	6,779	11,155	14,794	14,934	25,892	35,323	53,799
Chile	860	2,556	503	409	1,085	3,007	313	189	498	396	545
Colombia	1,906	830	1	0	9	326	227	678	1,339	1,267	1,913
Dominican Republic	1	0	0	0	0	0	0	33	0	0	0
Ecuador	0	0	0	0	0	0	0	1	0	0	86
Egypt	0	0	0	0	0	0	0	89	0	12	73
El-Salvador	2,688	1,733	1,191	1,392	1,735	1,418	1,851	1,879	653	742	587
Ethiopia	0	0	0	6,010	5,952	12,157	10,233	5,873	3,466	2,693	453
Ghana	174	156	83	119	216	401	683	1,007	989	1,137	1,050
Greece	8,523	7,608	10,594	10,051	6,144	8,920	9,068	8,302	10,845	7,675	8,424
Guatemala	24,636	24,989	24,515	22,788	19,801	34,211	16,597	21,062	18,538	10,490	15,368
Honduras	349	111	0	71	18	16	0	26	0	0	26
India	19,901	25,143	16,814	29,606	30,172	38,141	36,532	51,678	41,987	394,827	42,930
Indonesia	63,151	132,446	114,329	61,599	139,262	105,635	25,014	19,513	31,126	75,892	111,550
Ivory Coast	30	139	38	41	27	49	114	45	14	24	14
Israel	171	1,355	323	400	224	302	330	422	767	773	1,342
Italy	190,872	273,695	242,033	333,587	206,363	394,553	354,858	369,531	319,444	262,270	290,793
Malaysia	190,881	195,171	241,450	255,108	307,940	271,941	316,087	342,104	353,287	364,612	371,315
Mexico	72,080	88,648	81,438	153,428	115,448	116,304	143,289	121,465	114,841	125,910	186,369
Nicaragua	8,966	9,923	14,975	17,119	8,776	5,550	15,748	12,070	4,605	9,817	6,818

Table 23 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Nigeria	568	1,159	157	152	781	12	267	237	184	63	39
New Zealand	0	0	0	0	0	36	0	0	0	0	0
Pakistan	345	0	0	0	0	0	36	0	13	0	0
Paraguay	0	0	134	0	0	0	16	16	76	528	2,047
Peru	0	19	25	9	56	28	82	56	48	169	201
Philippines	2,133	2,353	102	7,029	5,854	3,934	9,806	3,503	12,897	1,869	603
South Africa	0	885	5,766	3,138	1,758	4,976	5,492	2,657	21	10	0
Spain	117,240	42,604	46,392	74,340	94,041	87,685	69,892	156,336	84,188	90,136	95,778
Thailand	772	750	659	830	851	850	911	1,010	1,034	1,163	1,093
Turkey	90,256	13,908	91,862	22,226	98,866	12,012	101,233	14,641	62,377	26,138	89,424
Venezuela	302	4,547	6,584	7,380	8,568	11,600	11,747	10,341	2,834	17,756	22,248
Vietnam	0	0	51	0	60	38	54	5	24	374	324

Appendix 1 table 24: U.S. Stimulant Imports by Commodity (raw equivalent weight – metric tons/year)

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Coffee	966,738	1,095,345	1,154,740	1,173,042	1,276,997	1,341,011	1,199,554	1,204,788	1,262,391	1,281,637	1,262,804
Tea	83,308	89,147	81,210	96,631	92,865	88,291	96,658	93,465	94,186	99,467	100,065
Cocoa	662,123	864,372	808,280	877,558	932,468	994,155	904,256	759,318	900,765	1,028,362	1,156,866
Sugar	14,606,486	26,542,058	26,744,337	18,687,623	14,596,954	13,437,269	12,335,720	12,689,428	13,837,677	13,377,842	19,345,684
TOTAL	**16,318,655**	**28,590,922**	**28,788,566**	**20,834,854**	**16,899,284**	**15,860,726**	**14,536,188**	**14,746,999**	**16,095,019**	**15,787,308**	**21,865,419**

Appendix 1 table 25: U.S. Stimulant 'Imported Land' by Commodity (hectares/year)

	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Coffee	1,601,807	1,654,945	1,727,941	1,769,088	1,907,970	1,702,151	1,507,572	1,464,850	1,604,939	1,556,111	1,484,661
Tea	75,801	80,377	68,665	74,306	72,425	70,121	70,092	68,154	69,981	71,884	70,340
Cocoa	1,444,524	1,617,631	1,490,968	1,511,798	1,612,392	1,858,188	1,738,512	1,319,623	1,586,592	1,632,349	1,795,288
Sugar	279,794	438,808	475,304	330,470	213,875	226,820	196,232	204,655	212,305	197,967	287,531
TOTAL	**3,401,926**	**3,791,761**	**3,762,878**	**3,685,662**	**3,806,662**	**3,857,281**	**3,512,407**	**3,057,281**	**3,473,818**	**3,458,311**	**3,637,820**

Appendix 1 table 26: U.S. Stimulant Imports by Country (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	877,143	1,142,068	1,270,303	1,311,080	226,964	427,759	442,162	641,283	439,762	424,148	513,283
Australia	1,267,587	2,417,235	1,202,148	1,362,930	692,250	849,319	768,827	812,592	726,572	816,835	922,030
Belize	132,187	217,349	356,572	215,223	128,477	103,386	365,278	430,480	335,705	100,911	103,296
Bolivia	148,266	87,510	162,383	101,145	75,890	56,821	75,015	151,382	74,374	1,079	155,625
Brazil	2,172,993	3,691,040	3,428,255	2,182,999	1,932,706	1,593,860	2,336,747	1,512,564	1,785,841	1,650,565	3,718,653
Burundi	4,953	196	4,155	2,670	3,050	4,436	1,906	833	5,453	166	2,583
Congo (Brazzaville)	0	50,743	216,704	0	64,123	64,726	0	64,726	64,840	64,845	64,696
Cameroon	6,883	7,667	4,206	3,605	2,699	7,194	2,420	8,472	9,247	8,464	10,104
China	41,315	55,643	64,735	59,817	59,770	37,636	34,320	34,663	33,728	36,102	44,566
Colombia	1,748,544	1,300,891	1,835,525	743,173	1,066,163	825,066	742,974	1,062,353	1,646,722	1,410,127	1,046,660
Costa Rica	256,374	1,522,574	741,842	924,215	732,665	673,904	266,318	201,389	420,695	1,255,867	487,213
Dominican Republic	1,730,617	3,108,525	4,481,517	2,750,994	1,346,113	1,872,846	1,432,059	1,603,785	1,686,191	1,676,303	1,661,799
Ecuador	236,841	498,721	122,055	182,823	185,201	156,688	151,450	31,833	146,516	156,209	146,665
El-Salvador	545,372	963,343	967,513	902,387	595,508	632,438	770,632	540,949	753,722	623,482	1,246,377
Ethiopia	6,524	8,203	18,465	11,011	4,627	5,478	4,793	4,409	6,100	7,311	10,677
Ghana	33,238	20,221	5,227	14,752	31,097	65,567	51,288	20,131	5,413	12,897	22,123
Guatemala	998,678	2,905,560	2,864,872	1,317,840	3,381,272	1,546,508	914,573	947,177	2,324,673	1,617,805	2,128,575
Haiti	822	816	1,591	2,049	1,544	1,560	1,732	2,585	2,558	2,346	1,683
Honduras	140,690	125,946	281,222	454,402	118,158	99,969	235,549	123,087	256,875	173,872	454,835
India	24,975	153,752	166,829	209,875	15,719	32,509	19,133	92,625	88,858	89,641	13,766
Indonesia	113,333	237,369	278,962	268,429	274,078	238,968	263,922	217,045	226,883	272,111	282,005
Ivory Coast	121,179	236,072	235,398	257,064	235,857	426,520	218,083	170,859	227,448	310,966	466,784
Jamaica	34,522	350,632	314,526	150,309	105,151	166	323	233	296	102,765	26,254
Kenya	6,349	10,386	10,196	10,167	8,514	9,878	10,651	10,135	8,898	7,333	8,061
Madagascar	66,506	25	209,465	7,697	67,877	67,231	60,074	52,441	490	835	89
Malawi	2,680	163,194	98,600	120,554	102,051	4,906	193,765	86,721	92,334	80,355	52,125

Table 26 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Malaysia	37,828	35,325	50,796	46,645	53,766	55,475	60,735	37,174	72,155	105,598	89,111
Mauritius	28,083	215,067	217,511	309,989	46,876	50,166	112,260	30,620	19,090	194,892	39,681
Mexico	378,886	631,756	477,219	662,751	1,050,354	963,695	1,241,929	1,768,073	273,646	261,042	2,221,251
Mozambique	429,948	228,776	548,849	188,673	0	240,468	116,815	122,085	119,990	121,632	134,795
Nicaragua	300,522	862,582	1,199,758	727,130	331,869	554,927	66,138	218,447	329,957	482,044	830,809
Nigeria	7,318	3,504	2,177	2,654	2,449	10	1,198	4,807	22,502	1,036	31,357
Pakistan	0	3	0	0	0	3	10	12	27	50	55
Paraguay	139,550	31,090	34,879	93,754	75,760	69,756	69,373	65,443	66,682	81,142	120,951
Peru	703,807	787,501	690,721	724,533	251,836	264,168	624,268	439,166	428,791	430,359	334,508
Panama	495,785	540,757	626,626	574,055	535,231	614,198	440,586	351,323	360,889	234,707	662,218
Papua New Guinea	81,906	13,408	74,046	84,760	98,381	79,824	25,147	148,082	79,897	86,329	85,547
Philippines	1,293,442	2,400,190	2,945,651	1,686,827	1,306,578	845,371	826,879	709,105	1,268,744	1,261,370	1,267,765
Rwanda	294	2,960	940	850	888	1,463	3,574	2,302	2,183	3,213	3,092
South Africa	216,851	1,194,696	187,796	645,801	141,188	427,419	288	574,804	218,670	216,238	281,650
Sri Lanka	5,240	4,229	3,308	4,446	4,646	4,183	3,251	3,414	3,731	3,771	3,573
Tanzania	970	779	707	924	758	1,197	1,261	671	2,300	1,880	2,455
Thailand	195,535	322,572	292,850	221,008	152,558	161,533	158,684	7,251	141,844	150,214	144,752
Turkey	9	12	22	1,240	955	917	1,179	689	1,102	871	1,732
Uganda	3,680	7,515	14,367	5,123	11,797	9,174	8,194	5,634	10,497	6,975	5,816
Venezuela	6,229	28,990	5,561	9,937	23,302	2,993	684	11,158	12,048	7,442	371
Vietnam	59,215	65,325	82,370	91,282	76,248	151,691	175,914	115,611	111,514	171,259	183,906
Zimbabwe	148,791	557,020	307,085	41,454	116,027	113,893	121,866	223,559	162	107,528	111,528

Appendix 1 table 27: U.S. Stimulant ‘Imported land’ by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	32,480	40,354	39,184	43,770	28,717	32,631	31,069	33,104	27,564	30,149	30,986
Australia	13241	24730	12070	13940	7219	9324	11020	11016	8799	9892	10125
Belize	3339	4567	7514	4436	2509	2167	8250	9013	7598	2097	2147
Bolivia	3090	2204	4612	2819	2495	1921	2419	4592	3262	1119	4605
Brazil	461494	406370	362644	317467	490249	379683	422902	414759	624485	514687	565217
Burundi	6793	247	5966	4388	3144	7673	3851	741	8681	143	13773
Congo (Brazzaville)	0	1352	6199	0	1568	1725	0	1727	1734	1734	1730
Cameroon	13246	12353	11810	5464	4639	11028	5955	10998	9817	10791	13571
China	31012	31507	26261	26462	21699	18370	19790	19603	22308	20087	20184
Colombia	177362	250037	284255	233472	312859	207301	217073	203428	215303	205933	215590
Costa Rica	55536	66964	49696	53765	44726	39624	46875	54761	56391	76470	59652
Dominican Republic	233303	251073	265154	237270	133649	146856	138550	118799	146695	119401	97437
Ecuador	354921	338050	332404	275050	241597	197699	220877	128214	181682	115353	81352
El-Salvador	27299	37258	52382	53293	41437	110584	52898	56187	69302	70729	63142
Ethiopia	7092	8918	20247	11970	5347	5955	5256	4891	6882	7873	11389
Ghana	82291	52686	17424	49174	93104	225263	177723	70639	16337	34998	56629
Guatemala	132292	148506	138312	108580	154753	140380	129761	116814	146058	125938	139768
Haiti	1769	1748	3410	4098	3087	3120	3624	5581	5116	5173	3711
Honduras	26672	23345	26087	48862	30071	53336	34490	30684	31686	38529	38314
India	33520	33160	23927	29770	12490	28753	15577	10381	10963	14790	9863
Indonesia	162172	327995	385347	293299	297652	276905	315523	235024	260297	339703	326674
Ivory Coast	229010	367281	300657	423122	337629	402633	299425	231720	305523	422634	546038
Jamaica	2196	6997	6560	3363	2805	344	605	439	269	2779	953
Kenya	7382	12881	18680	19064	12258	11465	21417	18786	20762	17208	16112
Madagascar	2078	27	12748	24678	8496	10441	8921	1659	1285	2443	92
Malawi	1495	3489	2247	3514	3444	2053	4215	3269	2696	2029	1658

Table 27 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Malaysia	50853	40144	59563	41196	52672	61911	66654	31241	61742	87812	71581
Mauritius	392	2936	2736	3968	875	717	1419	454	263	2642	549
Mexico	418738	478567	362634	392326	493867	476708	314112	301362	211950	198296	180326
Mozambique	34315	18108	47223	12794	0	16343	7885	9156	8999	9122	10110
Nicaragua	6185	16981	23475	23944	15642	45803	45039	43217	39899	67274	40991
Nigeria	28408	8016	5059	5329	8104	29	3403	14561	62458	3005	90985
Pakistan	0	2	0	0	0	1	6	7	16	29	33
Paraguay	3034	648	721	1942	1614	1847	1725	1371	1272	1472	2343
Peru	68681	50022	82577	88764	85608	93897	77219	77744	79126	74008	57373
Panama	31105	24292	23533	25124	31424	26365	24256	14857	18786	13398	22501
Papua New Guinea	32421	23556	17096	51611	76554	27064	45821	41624	20363	41811	39459
Philippines	28251	44267	46689	27550	21936	19269	15755	17737	21052	18353	15540
Rwanda	404	4755	1313	1145	1262	2053	5060	3278	3132	4655	4094
South Africa	3649	17412	2840	9118	2236	5968	152	8127	3667	3756	4114
Sri Lanka	4026	3069	2276	3000	3200	2585	2082	2320	2313	2578	2443
Tanzania	2774	1855	1785	2673	1884	3004	2821	1627	5111	3959	5168
Thailand	42145	44517	38326	34150	23087	33014	29060	12998	19258	29324	21949
Turkey	6	8	12	535	368	507	632	391	549	432	857
Uganda	5333	7308	17793	6621	12880	19245	10957	6484	18368	9900	8254
Venezuela	17914	75282	16661	30359	65177	9314	2099	32111	38280	21937	1194
Vietnam	42639	42202	34461	48019	37638	90787	94953	78234	70759	101699	119706
Zimbabwe	1,397	6,157	2,852	489	1,102	1,171	1,123	2,153	44	1,189	1,491

Appendix 1 table 28: U.S. Sugar Crop Imports (metric tons/year) from Specific Countries

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	851,952	1,115,180	1,241,323	1,275,348	190,929	392,508	402,253	603,432	405,728	385,662	475,734
Australia	1,267,587	2,417,235	1,202,148	1,362,930	692,250	849,319	768,827	812,592	726,572	816,835	922,030
Belize	132,187	217,349	356,572	215,221	128,477	103,386	365,258	430,476	335,705	100,911	103,296
Bolivia	148,266	87,360	161,860	100,817	75,222	56,217	74,269	150,060	72,798	0	154,442
Brazil	1,970,628	3,501,115	3,252,525	1,984,330	1,625,731	1,388,771	2,117,144	1,176,314	1,410,315	1,315,373	3,383,836
Congo (Brazzaville)	0	50,743	216,704	0	64,123	64,726	0	64,726	64,840	64,845	64,696
China	1,554	7,556	12,219	17,268	22,792	1,185	3,674	6,736	4,843	3,783	1,631
Colombia	1,597,370	1,115,330	1,633,886	530,969	856,899	632,595	542,437	845,464	1,411,051	1,183,905	800,289
Costa Rica	227,028	1,489,018	700,996	872,984	684,274	626,332	210,638	140,980	364,885	1,196,583	431,105
Dominican Republic	1,668,811	3,044,330	4,431,041	2,693,495	1,322,959	1,845,824	1,397,106	1,573,149	1,648,913	1,647,557	1,642,489
Ecuador	133,467	390,714	42,524	149,249	106,265	102,819	102,678	0	103,015	103,106	103,777
El-Salvador	528,319	939,212	937,465	872,332	562,511	559,905	740,216	512,787	719,629	592,069	1,221,996
Guatemala	900,163	2,800,562	2,749,497	1,223,939	3,252,295	1,403,688	792,125	849,610	2,203,325	1,520,351	2,023,529
Honduras	122,686	110,232	261,958	416,370	95,985	51,610	204,769	98,678	235,080	145,275	428,826
India	1,016	126,405	146,365	185,761	1,875	2,313	1,498	80,694	75,502	73,492	73
Jamaica	33,616	350,192	313,927	149,868	104,718	0	0	0	161	102,542	26,047
Malawi	0	159,382	95,669	115,375	96,608	0	187,831	81,593	88,239	76,899	48,843
Mauritius	28,083	215,067	217,511	309,989	46,876	50,166	112,260	30,620	19,090	194,892	39,681
Mexico	189,832	396,100	286,357	503,034	847,425	740,802	1,118,815	1,645,807	183,497	177,042	2,157,919
Mozambique	429,948	228,776	548,849	188,673	0	240,468	116,815	122,085	119,990	121,632	134,795
Nicaragua	299,387	860,141	1,194,901	718,075	321,002	525,820	38,812	197,208	303,637	451,888	809,745
Paraguay	139,550	31,090	34,879	93,754	75,760	69,756	69,373	65,443	66,682	81,142	120,951
Peru	666,518	760,997	643,579	671,623	195,735	201,713	576,365	385,309	377,729	380,389	297,031
Panama	487,243	535,364	622,096	567,459	527,370	607,661	434,455	347,130	354,643	230,217	658,154
Papua New Guinea	67,988	0	64,721	64,712	64,237	64,166	0	126,068	64,726	63,092	63,137
Zimbabwe	148,607	557,011	307,042	41,258	115,923	113,844	121,735	223,470	0	107,371	111,398
Philippines	1,289,245	2,395,898	2,941,606	1,684,093	1,304,167	842,250	824,389	705,183	1,266,360	1,259,781	1,267,765
South Africa,	216,645	1,194,220	187,387	645,387	140,937	427,026	0	574,589	218,313	215,991	281,515
Thailand	148,734	278,468	253,299	189,673	137,843	130,227	130,000	4	131,578	130,871	131,482

Appendix 1 table 29: U.S. Vegetable Imports by Commodity (fresh equivalent weight)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Asparagus	38,723	38,275	43,236	53,794	69,164	78,515	76,455	88,528	109,659	105,559	124,302
Eggplant	24,947	30,804	29,937	38,079	32,427	38,918	41,278	40,506	44,680	49,760	54,097
Broccoli	255,000	265,477	257,990	246,831	286,088	272,051	277,346	296,749	299,326	349,489	369,935
Cabbage	35,665	35,928	39,790	40,734	36,913	40,793	51,447	45,182	35,272	37,795	51,966
Carrots	107,341	107,448	111,936	90,602	92,414	89,541	105,625	101,614	99,980	118,619	109,337
Cauliflower	33,689	34,429	47,814	41,410	40,980	36,873	30,468	30,946	36,745	55,887	46,117
Celery	25,679	25,613	30,874	48,081	38,319	29,196	36,720	41,142	27,080	22,499	26,696
Cucumbers	270,948	327,268	330,251	358,098	378,709	383,693	397,686	420,125	448,209	466,002	475,150
Garlic	30,439	30,670	24,918	63,776	71,146	48,651	59,587	74,520	81,073	91,338	101,805
Ginger	15,538	14,328	13,836	14,036	15,580	19,056	19,076	21,116	27,349	29,002	32,027
Lettuce	28,802	20,363	30,805	24,898	26,004	29,311	36,470	63,595	57,732	57,744	77,513
Mushrooms	134,547	115,544	127,582	122,665	113,975	153,809	136,671	137,399	165,884	179,044	170,368
Okra	24,750	25,725	32,061	24,608	23,499	25,179	24,075	28,770	33,437	44,197	52,911
Onions	217,056	281,463	259,075	269,385	261,642	216,201	290,235	275,641	300,141	320,370	314,053
Potatoes	473,070	648,714	741,331	978,346	1,015,002	1,116,208	1,208,893	1,384,099	1,566,981	1,670,929	1,544,577
Peppers	269,120	324,351	337,993	396,214	409,677	423,431	445,631	510,663	548,926	571,027	633,246
Spinach	3,614	4,539	6,287	6,221	3,976	7,972	16,952	14,589	22,381	23,781	30,467
Sweet Potatoes	9,959	9,644	7,825	8,067	8,029	6,940	6,214	6,668	5,035	5,171	5,848
Tomatoes	908,359	973,840	1,013,730	1,238,648	1,322,891	968,587	1,112,783	1,214,140	1,233,476	1,260,203	1,267,052
TOTAL	**2,907,247**	**3,314,423**	**3,487,271**	**4,064,495**	**4,246,436**	**3,984,923**	**4,373,613**	**4,795,993**	**5,143,366**	**5,458,416**	**5,487,467**

Appendix 1 table 30: U.S. Vegetable ‘Imported land’ by Commodity (hectares / year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Asparagus	9,616	10,308	10,004	13,261	13,492	15,916	12,851	15,427	17,178	15,860	19,318
Eggplants	621	939	1,149	1,496	1,383	1,566	1,685	1,662	2,026	2,445	2,655
Broccoli	21,788	22,907	20,875	20,117	23,187	22,439	23,842	25,283	25,817	29,655	31,003
Cabbage	1,544	1,550	1,824	1,720	1,728	1,802	2,328	2,143	1,657	1,683	2,280
Carrots	3,644	3,606	3,852	2,896	3,142	3,089	3,449	3,249	3,228	3,884	3,649
Cauliflowers	2,837	2,900	3,717	3,121	3,091	2,898	2,385	2,482	2,849	4,210	3,588
Celery	1,216	1,181	1,418	2,286	1,692	1,186	1,569	1,718	1,058	865	1,041
Cucumbers	12,327	16,792	14,346	13,533	15,501	14,926	14,943	15,307	16,051	16,311	26,790
Garlic	3,810	3,565	2,943	7,450	7,844	5,330	6,137	7,067	6,383	6,681	7,271
Ginger	1,921	1,719	1,981	2,916	2,278	2,651	2,548	2,835	3,895	3,789	4,301
Lettuce	1,471	980	1,151	1,134	1,137	1,515	1,564	2,870	2,582	2,608	3,527
Mushrooms	1,106	975	1,003	842	537	714	600	655	844	1,006	908
Okra	3,407	3,995	4,446	4,284	4,050	4,449	4,093	4,995	5,709	7,449	8,904
Onions	17,119	19,724	19,104	19,189	17,804	14,594	19,180	17,637	19,405	19,966	19,529
Potatoes	13,388	16,983	20,077	26,714	27,047	28,883	47,614	50,015	52,848	53,879	51,048
Peppers	35,889	46,911	43,112	54,565	62,611	63,151	63,624	74,285	72,050	77,228	80,818
Spinach	302	374	506	572	627	816	1,410	1,431	1,979	2,161	2,802
Sweet Potatoes	2,004	1,819	1,552	1,419	1,082	1,009	1,005	1,074	810	842	930
Tomatoes	35,877	36,894	38,461	36,898	36,992	27,933	32,692	34,811	32,855	32,327	32,527
TOTAL	**169,889**	**194,122**	**191,522**	**214,410**	**225,223**	**214,866**	**243,519**	**264,947**	**269,227**	**282,851**	**302,888**

Appendix 1 table 31: U.S. Vegetable Imports by Country (fresh equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	3,416	3,478	3,028	10,578	22,685	5,865	8,337	8,441	10,918	9,535	7,852
Australia	0	0	3	81	12	93	1,471	1,044	48	967	436
Belize	14	44	138	63	94	73	237	47	47	34	83
Brazil	3,283	2,620	3,032	4,100	6,459	6,512	7,050	7,318	7,015	6,159	5,218
Canada	709,261	904,486	1,066,984	1,367,101	1,420,955	1,567,206	1,726,523	1,927,625	2,151,312	2,324,444	2,174,445
China	52,057	43,555	47,837	51,757	58,915	75,458	113,959	126,049	146,524	179,555	201,290
Chile	74,143	33,157	20,906	35,400	165,252	20,617	30,508	32,718	49,280	39,724	46,828
Colombia	3,447	4,412	3,343	3,883	3,006	3,132	2,523	3,575	3,481	5,438	4,718
Costa Rica	2,835	5,850	4,052	3,722	4,307	1,916	3,810	5,456	3,919	6,093	5,845
Dominican Republic	17,233	15,546	14,629	13,155	13,901	13,212	34,609	43,476	33,847	31,070	31,679
Ecuador	913	1,185	1,752	548	1,709	3,263	9,963	14,924	19,551	22,298	20,284
El-Salvador	396	603	774	1,009	1,686	358	1,324	1,243	2,595	3,743	2,844
Ethiopia	0	6	0	4	1	11	8	22	25	10	26
Guatemala	45,652	44,882	42,363	50,803	54,378	51,251	42,877	53,116	64,193	74,752	62,236
Honduras	14,308	11,982	6,510	8,693	7,087	17,949	16,214	23,034	22,337	48,474	48,936
India	9,892	14,519	19,025	16,309	26,176	29,342	28,440	30,121	28,755	36,211	33,113
Israel	56,320	41,219	29,918	45,981	59,422	23,266	30,723	33,087	31,448	28,003	31,437
Italy	39,969	47,244	79,020	88,249	43,448	36,660	11,056	13,665	8,327	10,773	11,172
Jamaica	479	385	259	555	371	391	204	150	493	112	243
Mexico	1,693,304	1,951,708	1,922,587	2,061,853	2,020,733	1,863,297	2,003,755	2,135,779	2,194,682	2,258,411	2,380,687
Nicaragua	1,545	1,739	1,563	663	361	671	2,097	392	733	0	410
New Zealand	621	2,643	1,040	778	744	652	776	1,357	3,097	1,190	1,464
Pakistan	20	41	252	361	203	416	631	218	569	303	214
Panama	175	155	155	155	177	211	101	487	499	155	304
Peru	12,806	22,659	26,133	36,552	82,287	60,885	77,473	98,231	111,417	125,131	146,773

Table 31 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Philippines	2	2	1	8	5	12	260	926	167	184	209
South Africa	114	206	522	871	482	931	944	1,724	1,513	1,076	1,069
Spain	7,307	13,098	21,071	29,233	27,886	26,913	29,436	31,024	19,872	18,192	16,644
Sri Lanka	153	153	153	153	153	153	28	26	11	0	0
Thailand	2,979	1,496	1,618	2,010	2,170	3,318	4,638	5,403	3,576	1,801	1,447
Turkey	4,279	6,370	5,562	11,952	7,779	8,018	8,998	11,077	13,745	17,725	33,779
Vietnam	261	138	0	44	304	314	603	916	242	632	555

Appendix 1 table 32: U.S. Vegetable ‘Imported Land’ by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	434	420	426	1,079	2,197	633	910	729	894	764	751
Australia	0	0	1	4	0	2	27	20	1	19	12
Belize	5	10	24	29	22	8	61	9	9	4	10
Brazil	62	88	81	79	426	417	485	799	670	691	649
Canada	20,254	24,192	28,950	35,489	35,858	38,756	60,116	62,983	67,144	68,730	64,524
China	651	621	788	1,823	2,769	3,745	5,809	6,417	6,885	7,616	8,424
Chile	3,029	2,197	1,863	2,442	4,934	2,378	2,224	2,520	3,267	2,657	2,096
Colombia	216	472	340	654	258	73	185	670	712	1,189	966
Costa Rica	109	250	21	42	148	33	107	323	520	1,149	820
Dominican Republic	2,793	2,357	2,003	1,718	1,303	1,294	2,218	2,753	2,161	2,069	2,141
Ecuador	135	160	311	94	257	369	626	715	815	634	472
El-Salvador	52	78	100	133	234	55	196	170	367	525	412
Ethiopia	0	14	0	11	2	27	20	55	63	25	65
Guatemala	1,168	967	1,050	889	1,006	1,244	1,141	1,483	1,631	1,791	2,332
Honduras	829	1,483	663	987	1,052	1,215	1,239	1,612	1,727	3,020	1,826
India	6,907	9,953	11,486	7,420	11,040	11,780	13,063	14,408	11,654	15,569	19,329
Israel	647	433	371	525	634	336	466	393	463	448	409
Italy	923	895	1,731	1,795	821	700	217	323	181	242	258
Jamaica	93	71	47	108	75	77	37	29	93	18	42
Mexico	95,415	112,093	104,920	117,232	118,094	109,488	109,680	118,713	118,862	119,231	126,908
Nicaragua	573	287	172	247	96	114	754	230	519	260	354
New Zealand	25	122	69	37	30	74	44	251	118	136	70
Pakistan	3	16	153	225	141	195	370	254	314	154	103
Panama	41	39	37	33	33	39	9	113	279	54	133
Peru	2,109	2,671	2,198	2,791	4,947	5,440	5,927	8,120	9,207	11,153	15,392
Philippines	0	0	0	1	1	3	95	318	58	4	75
South Africa	50	129	364	627	314	498	517	1,125	930	749	775

Table 32 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Spain	994	1,726	1,873	2,487	1,867	2,497	2,552	2,642	1,441	2,184	2,040
Sri Lanka	17	18	17	16	16	16	3	3	1	0	7,027
Thailand	68	105	120	76	77	230	528	650	118	127	133
Turkey	283	319	297	497	368	2,417	461	522	674	874	1,550
Vietnam	0	5	0	14	1	0	12	24	26	46	39

Appendix 1 table 33: U.S. Potato Imports (metric tons/year) and Imported Land (hectares) from Specific Countries

		1995	1996	1997	1998	1999	2000		1995	1996	1997	1998	1999	2000
Brazil	Mt	35	11	5	0	3	10	Ha	3	1	0	0	0	1
Canada	Mt	464,216	643,726	734,381	968,004	1,004,966	1,096,609	Ha	13,224	16,916	19,801	26,569	26,702	28,303
Columbia	Mt	43	23	7	13	59	94	Ha	1	1	0	0	2	2
Dominican Republic	Mt	45	0	0	0	0	0	Ha	7	0	0	0	0	0
Ecuador	Mt	280	305	1,249	346	882	1,186	Ha	50	54	222	61	157	211
India	Mt	0	6	64	40	403	760	Ha	0	1	7	4	41	72
Italy	Mt	2,791	163	47	6	302	2,720	Ha	99	6	2	0	10	90
Mexico	Mt	0	0	0	0	25	255	Ha	0	0	0	0	2	21
Netherland	Mt	57	192	1,165	1,763	423	1,607	Ha	1	4	22	28	8	26
Peru	Mt	72	19	10	0	8	17	Ha	3	1	0	0	0	1
Spain	Mt	0	0	885	2,161	5,348	6,833	Ha	0	0	22	51	124	156
Other Countries	Mt	5,531	4,268	3,518	6,012	2,582	6,116	Ha	354	256	217	376	168	373

Table 33 (continued)

		2001	2002	2003	2004	2005		2001	2002	2003	2004	2005
Brazil	Mt	5	22	0	223	0	Ha	0	1	0	11	0
Canada	Mt	1,193,313	1,367,590	1,533,371	1,621,872	1,489,117	Ha	47,120	49,674	52,508	53,488	50,661
Columbia	Mt	204	126	183	281	550	Ha	12	7	10	16	32
Dominican Republic	Mt	205	0	50	8	0	Ha	11	0	3	0	0
Ecuador	Mt	1,035	37	0	0	5	Ha	106	4	0	0	0
India	Mt	306	457	942	500	261	Ha	17	23	52	28	15
Italy	Mt	341	1,251	372	1,493	1,858	Ha	14	52	17	59	74
Mexico	Mt	282	499	140	69	744	Ha	12	21	6	3	30
Netherland	Mt	2,256	3,619	5,016	3,244	2,047	Ha	52	80	123	71	48
Peru	Mt	17	19	34	166	190	Ha	1	2	2	14	16
Spain	Mt	6,971	4,187	3,332	5,314	4,781	Ha	268	150	126	188	172
Other Countries	Mt	3,959	6,293	23,540	37,758	45,024	Ha	249	379	1,414	2,167	2,595

Appendix 1 table 34: U.S. Tomato Imports (metric tons/year) and Imported Land (hectares) from Specific Countries

		1995	1996	1997	1998	1999	2000		1995	1996	1997	1998	1999	2000
Australia	Mt	0	0	0	67	12	92	Ha	0	0	0	1	0	2
Brazil	Mt	272	12	4	24	5	359	Ha	6	0	0	1	0	7
Canada	Mt	99,302	94,150	132,121	190,442	201,821	227,202	Ha	1,736	1,523	2,106	2,325	2,486	2,540
China	Mt	8	30	73	6,925	32,114	9,284	Ha	0	1	3	287	1,344	362
Chile	Mt	51,813	15,784	7,458	21,597	146,158	3,947	Ha	939	250	117	338	2,230	67
Costa Rica	Mt	130	184	322	354	236	117	Ha	3	5	8	14	13	4
Dominican Republic	Mt	5,550	4,247	5,102	3,610	4,847	4,957	Ha	258	164	192	101	175	178
Israel	Mt	54,802	39,322	26,618	40,932	54,716	18,086	Ha	614	387	298	415	530	215
Italy	Mt	36,787	46,637	78,369	87,740	42,628	33,123	Ha	816	883	1,620	1,773	796	603
Mexico	Mt	633,159	729,409	701,253	792,471	736,768	636,664	Ha	28,759	31,305	31,087	27,725	25,228	22,777
Peru	Mt	0	0	3,550	7,077	26,775	6,660	Ha	0	0	130	320	1,099	212
Spain	Mt	3,424	7,692	14,928	17,597	10,577	7,202	Ha	67	131	257	298	173	119
Turkey	Mt	2,074	4,070	2,578	6,170	3,403	3,749	Ha	50	98	62	149	84	95
Other Countries	Mt	21,040	32,305	41,353	63,642	62,831	17,147	Ha	788	1,154	1,569	2,434	2,281	631

Table 34 (continued):

		2001	2002	2003	2004	2005		2001	2002	2003	2004	2005
Australia	Mt	1,443	1,044	48	960	391	Ha	26	20	1	17	7
Brazil	Mt	1,118	2,417	2,517	1,590	17	Ha	21	41	43	27	0
Canada	Mt	242,413	268,115	302,342	346,561	330,732	Ha	3,101	3,133	3,614	3,578	3,415
China	Mt	41,728	34,962	6,788	2,280	9,303	Ha	1,617	1,294	248	95	384
Chile	Mt	11,095	5,896	1,485	1,119	8,605	Ha	161	89	23	17	129
Costa Rica	Mt	0	9	3	154	711	Ha	0	0	0	3	14
Dominican Republic	Mt	23,149	32,347	25,682	23,903	23,683	Ha	889	1,179	987	901	893
Israel	Mt	19,261	20,537	15,144	12,451	21,039	Ha	230	150	125	105	177
Italy	Mt	9,752	11,222	6,841	8,400	8,275	Ha	185	238	134	159	150
Mexico	Mt	705,681	778,117	833,432	829,796	837,821	Ha	24,068	26,344	26,027	25,914	26,164
Peru	Mt	3,583	3,898	480	635	1,175	Ha	138	156	16	25	47
Spain	Mt	8,105	11,309	3,825	2,587	518	Ha	129	168	61	41	8
Turkey	Mt	4,385	5,457	6,115	4,779	8,824	Ha	117	147	162	129	237
Other countries	Mt	41,069	38,811	28,774	24,987	15,957	Ha	1,534	1,368	1,035	889	564

Appendix 1 table 35: U.S. Fiber Imports by Commodity (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cassava	56,725	68,198	58,185	63,961	75,972	78,055	78,832	90,022	102,817	102,954	109,542
Cotton	1,859,999	1,924,017	2,315,663	2,744,137	3,059,649	3,441,353	3,433,216	3,874,897	4,210,220	4,340,560	
Jute	46,425	26,358	25,642	33,929	32,353	35,968	24,850	27,504	26,974	28,400	30,201
Rubber	1,044,229	1,033,680	1,067,248	1,199,673	1,143,106	1,216,060	992,451	1,213,172	1,119,839	1,158,031	1,168,988
Sisal	84,396	57,845	78,371	39,966	37,294	53,874	45,346	41,678	58,112	57,230	37,292
Tobacco	190,291	302,385	294,230	223,503	219,665	215,561	232,964	260,230	288,056	253,832	233,100
TOTAL	**3,282,065**	**3,412,483**	**3,839,339**	**4,305,168**	**4,568,040**	**5,040,871**	**4,807,658**	**5,507,504**	**5,806,018**	**5,941,007**	**1,579,123**

Appendix 1 table 36: U.S. Fiber 'Imported Land' by Commodity (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cassava	4,213	4,703	3,967	4,465	4,896	5,115	5,305	6,062	6,327	6,350	7,325
Cotton	1,208,730	1,262,893	1,665,794	1,894,301	1,890,341	2,323,118	2,310,438	2,745,176	2,581,596	2,625,574	2,625,574
Jute	25,967	12,517	13,599	18,736	17,076	17,732	11,632	13,578	13,011	13,896	14,899
Rubber	1,335,841	1,302,944	1,355,540	1,481,075	1,305,988	1,437,140	1,171,750	1,433,247	1,396,050	1,463,292	1,518,096
Sisal	100,728	65,575	82,896	51,333	38,321	49,172	50,611	46,791	67,220	66,626	40,836
Tobacco	109,146	215,260	204,596	165,002	154,013	151,836	178,746	204,740	194,496	178,586	166,762
TOTAL	**2,784,625**	**2,863,891**	**3,326,391**	**3,614,911**	**3,410,635**	**3,984,113**	**3,728,482**	**4,449,594**	**4,258,701**	**4,354,324**	**4,373,492**

Appendix 1 table 37: U.S. Fiber Imports by Country (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	9	23,780	26,039	11,298	14,407	17,300	16,907	23,623	26,560	20,757	26,083
Australia	13,053	4,871	5,369	10,211	7,448	8,251	15,566	12,262	9,250	8,252	8,252
Bangladesh	20,856	10,434	11,125	17,289	17,347	18,045	12,035	13,401	12,641	15,610	15,003
Brazil	122,812	140,520	140,310	74,068	103,920	132,598	117,043	162,768	206,337	174,650	155,742
Sri Lanka	47	0	0	27	54.2	44.3	36.2	63.3	21.5	0.4	0
Cameroon	4,824	7,002	8,689	3,776	3,562	3,347	2,885	3,473	4,602	4,044	4,920
Canada	4046.5	4540.4	6631	8206	8585	7195	11330	11510	10455	8793.4	6514
Chile	2,493	2,360	1,713	1,611	0	0	0	0	108	368	0
China	179,458	160,701	208,135	205,046	222,855	219,079	217,549	408,637	533,164	600,023	600,698
Colombia	841	1,559	1,191	813	807	638	908	862	2,038	2,040	1,296
Costa Rica	29,311	36,010	36,018	35,421	38,783	40,790	43,876	47,772	52,771	55,413	57,644
Dominican Republic	5,535	7,037	9,503	8,397	7,249	7,185	5,631	3,631	6,211	6,422	5,004
Ecuador	877	376	714	1,334	434	1,126	2,309	2,396	1,130	2,185	5,726
Egypt	51,223	34,332	45,315	63,551	48,493	65,171	69,574	69,022	75,058	57,721	57,721
Ghana	453	1,218	1,700	223	720	230	175	151	549	789	1,158
Greece	24,165	13,506	14,579	10,238	7,016	10,296	7,132	7,901	9,244	7,984	9,631
Guatemala	4,406	9,054	8,648	6,070	3,516	3,559	2,398	5,834	3,927	6,141	2,848
Haiti	2,992	3,257	2,105	2,285	1,353	846	745	389	1,282	1,097	1,667
Honduras	1,095	2,646	1,703	2,828	2,124	4,788	5,649	2,456	1,295	842	1,525
Indonesia	634,268	650,843	654,581	729,085	629,433	615,788	549,460	617,619	640,439	689,330	742,420
India	165,810	179,919	204,013	224,766	236,038	254,250	227,821	274,956	279,234	326,768	330,721
Italy	10,629	4,300	3,773	5,027	2,628	3,760	3,728	3,456	6,746	6,455	6,934
Ivory Coast	7,313	14,819	9,287	6,313	5,917	2,556	561	808	1,212	4,624	3,054
Jamaica	0	0	17	4	9	7	12	10	9	15	9
Madagascar	343	576	1,120	1,346	1,983	111	0	0	0	0	0

Table 37 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Malaysia	128,425	124,656	133,806	132,855	121,717	133,120	79,183	95,923	96,304	82,195	83,523
Malawi	8,938	17,857	22,935	8,315	16,057	16,890	16,462	20,028	22,029	16,657	17,339
Mexico	8,284	18,648	15,168	15,099	13,340	10,061	8,127	7,629	6,997	7,249	5,242
Nicaragua	251	129	353	475	202	818	381	299	167	390	500
Nigeria	19,336	18,352	10,697	4,910	1,293	1,199	360	7	634	3,889	2,502
Panama	0	0	117	338	20	8	121	82	131	113	106
Pakistan	133,990	162,581	219,588	291,352	311,516	409,417	429,773	479,448	503,648	586,988	587,198
Peru	0	9	0	0	0	0	2	0	0	3	10
Philippines	3,574	3,484	4,351	3,445	3,639	4,336	4,596	4,586	5,272	6,465	6,599
Spain	10,273	8,122	7,250	8,506	6,766	9,729	9,012	8,995	6,332	6,673	6,398
Thailand	256,874	244,189	259,525	292,984	264,759	394,109	298,154	423,279	323,465	329,466	277,728
Turkey	81,124	116,404	126,834	135,878	145,790	141,799	150,948	152,624	128,449	121,776	111,485
Tanzania	2,968	1,090	319	334	868	1,225	374	277	11	1,561	272
Uzbekistan	96	59	186	624	5,167	18,615	19,112	22,844	16,949	10,050	10,050
Venezuela	0	40	458	171	94	42	44	50	46	20	1
Vietnam	884	349	2,070	2,292	4,280	7,937	5,001	17,006	15,143	16,338	19,674
Zimbabwe	1,539	9,202	7,580	5,381	10,052	2,582	5,999	7,043	6,241	2,043	434

Appendix 1 table 38: U.S. Fiber ‘Imported Land’ by Country (hectares/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	5,626	14,686	15,625	9,121	9,609	9,487	12,353	24,773	16,728	13,956	13,186
Australia	9,429	3,171	3,535	7,915	4,675	5,397	9,056	7,097	5,248	4,107	4,107
Bangladesh	12,950	5,999	6,083	10,181	9,963	9,864	6,407	7,322	6,502	8,536	8,204
Brazil	171,291	140,240	134,894	83,113	83,285	109,817	90,724	123,151	165,806	137,657	117,710
Sri Lanka	9,913	9,774	13,878	6,042	6,129	4,105	3,087	7,976	8,123	9,814	5,703
Cameroon	8,037	9,916	11,950	5,379	4,723	4,736	4,051	4,884	6,445	5,610	6,837
Canada	1,466	1,663	2,446	3,102	3,089	3,230	4,586	3,996	3,609	3,254	2,424
Chile	790	692	539	580	0	0	0	0	38	117	0
China	200,684	178,358	202,720	202,992	216,542	200,013	196,000	346,975	559,625	539,779	539,779
Colombia	409	774	663	432	314	209	359	321	798	843	349
Costa Rica	1,954	2,401	2,401	2,361	2,586	2,719	2,925	3,185	3,518	3,694	3,843
Dominican Republic	5,274	4,680	4,837	5,729	5,545	5,473	4,277	2,770	4,473	4,791	3,580
Ecuador	260	126	133	354	166	495	749	769	466	754	1,591
Egypt	63,287	38,426	47,833	91,704	56,415	63,080	64,750	71,883	84,376	58,959	58,959
Ghana	674	1,444	2,158	155	899	153	95	12	43	306	416
Greece	11,225	6,867	7,131	4,928	3,262	4,598	3,094	3,537	3,895	3,339	4,242
Guatemala	3,722	6,264	5,811	2,957	1,813	1,691	1,248	2,919	2,149	3,790	1,947
Haiti	5,557	5,984	3,840	4,198	2,492	1,558	1,369	717	2,351	2,194	3,335
Honduras	1,538	3,827	1,970	6,558	5,714	10,658	12,789	1,706	888	506	931
Indonesia	935,937	928,627	957,322	1,057,676	900,785	914,821	815,249	963,235	997,895	1,072,037	1,155,773
India	605,233	636,611	921,943	941,007	991,972	1,243,450	1,151,828	1,356,618	889,287	1,109,376	1,111,510
Italy	4,245	1,576	1,393	1,801	836	1,123	1,120	1,065	1,974	1,849	2,395
Ivory Coast	12,185	20,989	12,775	9,057	8,070	3,646	797	1,110	1,689	6,516	4,264
Jamaica	0	0	1	0	0	0	1	1	0	1	1
Madagascar	818	1,297	1,617	1,939	2,939	141	0	0	0	0	0
Malaysia	174,011	165,756	192,805	214,601	221,706	270,534	176,748	192,617	193,382	165,051	167,708
Malawi	7,626	15,208	16,726	7,659	23,111	22,205	25,360	46,148	32,312	37,568	38,603
Mexico	11,817	20,513	13,525	14,561	14,053	5,138	8,006	6,603	6,138	6,730	4,919

Table 38 (continued)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Nicaragua	48	93	275	188	113	501	226	151	88	142	113
Nigeria	32,209	25,958	14,669	7,007	1,757	1,699	489	1	596	5,313	3,279
Panama	0	0	13	32	2	1	9	7	10	8	8
Pakistan	222,857	321,051	415,812	569,227	486,075	656,609	741,793	771,179	880,903	772,313	772,654
Peru	0	1	0	0	0	0	0	0	0	0	1
Philippines	2,954	2,662	3,179	2,464	3,166	3,247	3,624	3,324	3,770	4,219	3,923
Spain	9,764	7,055	6,607	7,014	5,156	9,020	7,838	7,375	5,770	5,759	5,680
Thailand	170,854	156,654	170,696	192,708	165,462	239,420	178,435	254,189	185,838	190,570	158,079
Turkey	76,150	117,858	120,881	132,133	138,827	121,746	141,418	135,557	107,401	106,402	98,815
Tanzania	0	1	379	280	1,064	1,673	532	337	0	1,540	197
Uzbekistan	113	81	260	833	7,679	26,889	27,340	32,204	24,966	12,721	12,721
Venezuela	0	33	106	57	22	3	8	20	7	6	1
Vietnam	1,902	627	3,644	4,247	6,577	10,897	6,232	21,365	18,647	20,181	24,389
Zimbabwe	1,258	7,393	5,502	4,927	13,837	3,108	8,292	16,061	8,628	4,466	936

Appendix 1 table 39: U.S. Cotton Imports by Country (raw equivalent weight – metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Argentina	898	474	404	455	242	346	509	5,980	2,506	2,013
Australia	13,053	4,871	5,369	10,211	7,448	8,251	15,566	12,262	9,250	8,252
Brazil	27,564	16,655	12,258	9,477	18,668	28,500	15,835	33,024	41,197	38,918
China	176,476	158,750	207,776	204,895	222,548	218,617	216,913	407,651	532,091	599,210
Egypt	51,223	34,332	45,315	63,551	48,493	65,171	69,574	69,022	75,058	57,721
India	143,029	166,877	190,139	208,165	221,367	235,830	213,581	259,453	265,430	312,012
Kazakhstan	79	16	53	85	238	401	464	824	2,222	2,979
Kyrgyzstan	0	0	0	1	14	116	77	308	1,059	980
Madagascar	343	576	1,025	1,116	1,913	0	0	0	0	0
Mali	67	82	62	58	47	69	45	36	31	49
Malawi	93	299	15	12	252	626	734	450	1,067	971
Pakistan	133,990	162,581	219,588	291,352	311,516	409,414	429,771	479,441	503,642	586,988
Spain	10,246	8,122	6,716	7,239	5,534	9,316	8,853	8,507	5,840	5,818
Syria	22	13	6	64	281	441	1,428	54	251	256
Turkey	45,798	43,536	50,223	69,146	104,504	104,502	103,890	106,061	90,530	78,149
Turkmenistan	174	0	0	100	1,041	5,226	6,339	8,245	9,985	11,171
Uzbekistan	96	59	186	624	5,167	18,615	19,112	22,844	16,949	10,050
Rest of the world	1,256,849	1,326,774	1,576,529	1,877,585	2,110,376	2,335,911	2,330,525	2,460,735	2,653,111	2,625,023

Appendix 1 table 40: U.S. Beef and Lamb Imports (metric tons/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	69,776	62,086	60,370	51,590	68,068	56,282	40,933	34,515	35,227	47,023	44,484
Australia	333,367	275,639	323,162	433,642	439,497	521,079	585,555	580,380	573,645	572,753	477,094
Brazil	28,105	36,274	39,492	55,843	83,977	71,856	68,213	82,680	84,614	89,362	87,989
Canada	206,404	271,959	332,719	387,266	449,248	435,547	464,834	514,993	348,251	499,104	514,082
Costa Rica	27,495	25,534	17,251	13,021	18,028	17,599	14,330	11,837	14,233	11,112	12,095
Honduras	8,305	8,517	7,179	1,288	641	387	846	320	106	2,240	1,880
Italy	48	73	3	21	67	129	2	0	6	48	0
Mexico	2,991	6,669	5,777	6,133	7,209	7,319	8,986	8,788	9,609	10,328	13,342
New Zealand	282,239	248,021	282,545	294,212	278,225	315,605	316,276	304,595	328,221	329,533	303,023
Nicaragua	24,145	16,839	18,882	10,008	10,664	15,041	17,788	19,962	22,861	30,752	29,814
Uruguay	3,753	32,629	31,479	22,973	30,596	28,709	18,456	5,663	46,782	188,205	259,280
TOTAL	**986,629**	**984,240**	**1,118,858**	**1,275,996**	**1,386,220**	**1,469,554**	**1,536,220**	**1,563,734**	**1,463,555**	**1,780,461**	**1,743,083**

Appendix 1 table 41: U.S. Live Cattle Imported (head)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Canada	1,132,691	1,510,285	1,378,825	1,316,213	989,885	968,435	1,308,670	1,688,814	513,344	135	561,820
Mexico	1,653,408	456,246	669,409	720,439	959,840	1,222,569	1,130,168	816,460	1,239,531	1,370,476	1,256,381

Appendix 1 table 42: U.S. 'Imported Pasture Land' (hectares)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Argentina	2,519,948	2,279,900	2,202,874	2,085,109	2,495,249	2,065,630	1,660,874	1,382,370	1,341,744	1,738,656	1,644,790
Australia	18,230,638	15,099,095	16,803,092	22,168,964	21,209,092	26,004,914	27,612,655	28,602,989	28,757,686	29,650,416	25,955,100
Brazil	949,733	1,134,961	1,295,528	1,878,215	2,560,057	2,142,983	1,969,258	2,281,210	2,305,189	2,264,337	2,229,568
Canada	6,711,061	7,613,592	7,724,238	7,792,216	7,506,758	7,358,171	8,155,067	8,950,238	5,976,045	4,815,633	6,755,952
Costa Rica	685,877	618,605	467,804	370,867	497,197	499,871	449,834	403,604	448,023	376,638	409,940
Honduras	198,031	192,116	171,769	34,018	17,636	10,607	22,755	7,777	2,797	62,520	52,480
Italy	177	265	12	78	245	482	9	0	22	184	0
Mexico	15,395,669	5,654,645	7,958,926	8,318,104	10,650,558	12,905,174	11,954,312	8,932,522	12,768,383	14,103,876	13,104,886
New Zealand	889,129	799,640	878,623	956,989	1,009,631	1,109,731	1,085,784	1,124,959	1,108,838	1,098,333	965,357
Nicaragua	2,276,284	1,564,569	1,667,891	937,940	993,074	1,072,296	1,208,527	1,306,759	1,472,519	1,843,718	1,787,453
Uruguay	131,698	1,052,514	893,728	648,544	891,311	831,864	782,134	186,221	1,489,275	5,980,233	8,238,629
TOTAL	**47,988,245**	**36,009,902**	**40,064,486**	**45,191,046**	**47,830,807**	**54,001,723**	**54,901,209**	**53,178,648**	**55,670,521**	**61,934,542**	**61,144,156**

Appendix 1 table 43: U.S. Wood Import (cubic meter/year)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Lumber	72,065,000	75,443,000	75,744,000	79,022,000	81,653,000	83,340,000	85,153,000	89,323,000	90,740,000	99,922,000	104,339,000
Plywood & Veneer	3,035,000	2,752,000	3,234,000	3,700,000	4,277,000	4,357,000	4,973,000	5,909,000	7,238,000	10,763,000	12,636,000
Wood Pulp	35,261,000	32,383,000	35,385,000	38,311,000	41,783,000	41,783,000	41,538,000	40,632,000	40,632,000	40,632,000	40,632,000
Logs	364,000	521,000	578,000	839,000	1,333,000	2,098,000	2,146,000	2,576,000	2,321,000	2,084,000	3,235,000
TOTAL	**110,725,000**	**111,099,000**	**114,941,000**	**121,872,000**	**129,046,000**	**131,578,000**	**133,810,000**	**138,440,000**	**140,931,000**	**153,401,000**	**160,842,000**

Appendix 1 table 44: U.S. 'Imported Forest Land' from Canada (hectares)

1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
95,370,707	97,437,765	97,612,270	101,327,240	105,337,765	107,311,220	107,869,580	109,628,593	109,366,697	109,053,231	113,773,836

Appendix 2 table 1: Costa Rica Agricultural Production (fresh or raw equivalent weight)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Cassava	60,000	46,380	345,000	295,000	233,000	300,500	355,000	235,000	194,800
Potatoes	66,737	49,500	54,487	64,678	52,661	43,235	43,606	55,124	53,814
Yams	6,000	5,000	13,000	12,416	27,200	23,360	14,749	8,395	16,088
Sugar Cane	2,370,000	2,630,000	2,830,000	3,040,000	3,180,000	3,200,000	3,640,000	3,350,000	3,880,000
Coconuts	27,600	27,800	28,000	28,500	16,000	16,000	16,000	16,000	16,000
Oil Palm Fruit	251,637	332,600	359,389	356,890	364,000	474,598	490,000	422,000	489,000
Cabbages	9,220	9,300	9,400	9,500	9,600	9,700	9,800	9,800	9,800
Ginger	2,000	2,500	2,500	2,500	4,560	10,400	20,660	11,993	15,535
Onions	15,212	16,145	20,393	22,447	25,637	28,334	16,139	16,369	12,908
Tomatoes	8,500	9,000	10,454	8,864	8,665	8,395	8,319	8,424	10,054
Pepper	3,870	3,868	10,950	10,170	10,452	2,944	3,000	3,000	3,000
Avocados	22,000	23,000	23,000	23,200	23,300	23,400	23,500	24,000	24,000
Bananas & Plantains	1,538,800	1,768,140	1,765,560	1,966,900	2,050,250	2,043,550	2,343,435	2,448,930	2,352,425
Berries	3,000	2,750	1,250	1,000	1,000	1,000	1,000	1,000	1,000
Grapefruit	0	0	0	0	0	0	0	0	0
Lemons	0	0	0	0	0	0	0	0	0
Mango	7,000	8,000	12,250	13,877	14,682	15,118	16,565	20,475	11,434
Melons & Watermelons	50,450	73,600	79,950	121,855	127,124	165,000	150,000	165,000	197,076
Oranges	83,000	110,690	133,000	134,000	160,000	129,573	150,000	165,000	298,483
Papayas	25,200	16,436	24,520	21,000	42,762	60,665	56,000	56,000	56,000
Pineapples	455,000	423,500	420,000	490,000	490,000	490,000	424,480	573,650	641,918
Strawberries	0	1,750	1,250	1,000	1,000	1,250	1,500	1,500	1,500
Coffee	157,000	151,100	158,000	168,000	156,927	147,998	150,061	154,131	132,015
Cocoa	4,270	3,500	3,400	3,000	2,800	2,000	2,000	2,000	800
Other	277,240	322,078	301,910	281,109	245,972	278,804	245,986	289,223	297,985
TOTAL	**5,443,736**	**6,036,637**	**6,607,663**	**7,075,906**	**7,247,592**	**7,475,824**	**8,181,800**	**8,037,014**	**8,715,635**

Table 1 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Cassava	320,245	395,000	276,000	435,000	388,000	352,600	295,000	300,000
Potatoes	79,495	68,854	77,959	89,198	86,785	81,678	80,000	80,000
Yams	34,546	13,050	17,856	20,000	20,000	20,000	20,000	20,000
Sugar Cane	3,870,000	3,560,000	3,600,000	3,670,000	3,670,000	4,160,000	3,945,000	3,945,000
Coconuts	16,000	17,500	17,500	18,000	19,000	19,500	19,500	19,500
Oil Palm Fruit	444,000	492,000	609,117	666,084	692,398	860,000	1,080,000	1,110,000
Cabbages	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
Ginger	21,315	1,225	3,788	4,163	4,000	4,000	4,000	4,000
Onions	13,416	21,513	15,445	32,913	28,404	26,386	33,269	33,269
Tomatoes	31,676	19,150	27,319	49,746	55,578	47,000	50,000	50,000
Pepper	1,504	1,564	1,469	1,321	1,370	1,370	1,370	1,370
Avocados	23,000	23,000	24,000	24,000	24,000	25,000	25,000	25,000
Bananas & Plantains	2,555,920	2,490,229	2,307,373	2,195,000	2,117,000	2,098,000	2,290,000	2,290,000
Berries	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Grapefruit	0	16,000	17,875	17,920	17,920	17,920	17,920	17,920
Lemons, Limes	0	1,000	4,614	10,000	10,000	16,000	16,000	16,000
Mango	8,076	13,139	32,800	32,000	36,000	36,000	36,000	36,000
Melons & Watermelons	223,564	246,753	270,717	285,000	287,000	322,000	292,000	292,000
Oranges	329,432	283,195	405,000	436,564	367,000	367,000	367,000	367,000
Papayas	15,764	33,195	28,786	27,239	26,458	26,458	26,458	26,458
Pineapples	651,000	857,969	903,125	950,400	992,000	1,100,000	725,224	725,224
Strawberries	1,500	600	600	600	3,160	3,160	3,160	3,160
Coffee	152,385	147,868	161,395	150,289	140,874	132,259	126,000	126,000
Cocoa Beans	849	888	708	708	708	708	708	708
Other	278,166	341,217	332,679	256,549	216,454	246,340	271,842	239,509
TOTAL	**9,082,453**	**9,055,509**	**9,146,725**	**9,383,294**	**9,214,709**	**9,973,979**	**9,736,051**	**9,738,718**

Appendix 2 table 2 Costa Rica Land required for each Crop (hectares)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Cassava	4,300	3,092	23,000	19,660	15,533	20,033	23,660	15,666	12,986
Potatoes	3,224	2,250	2,293	2,602	2,187	2,039	2,194	2,528	2,241
Yams	350	500	400	900	776	1,700	1,168	819	466
Sugar Cane	40,000	29,500	37,000	38,000	38,700	39,800	42,830	42,900	44,200
Coconuts	4,000	4,500	4,450	5,000	3,500	3,000	3,000	3,000	3,000
Oil Palm Fruit	20,000	23,183	23,891	24,600	26,600	26,652	28,190	27,239	26,586
Macadamia	0	8,355	8,988	9,188	6,680	6,700	6,300	5,800	6,000
Cabbages	1,230	1,240	1,250	1,260	1,270	1,280	1,300	1,300	1,300
Ginger	150	160	160	160	285	600	1,033	923	1,195
Onions	591	746	627	1,113	726	606	732	658	721
Tomatoes	240	250	261	222	217	210	208	211	252
Pepper	500	499	650	498	488	486	450	450	450
Avocados	3,900	4,100	4,100	4,200	4,300	4,400	4,500	4,500	4,500
Bananas & Plantains	28,722	36,017	40,200	45,119	56,894	59,207	58,665	59,000	56,691
Berries	70	50	70	50	50	50	50	50	50
Grapefruit	0	0	0	0	0	0	0	0	0
Lemons, Limes	0	0	0	0	0	0	0	0	0
Mango	3,900	4,100	4,754	6,693	6,696	6,814	7,796	7,945	7,472
Melons & Watermelons	2,300	3,475	4,100	5,805	6,118	6,609	6,397	6,871	8,388
Oranges	6,857	10,757	13,065	16,000	18,000	22,250	22,500	23,500	23,500
Papayas	840	520	613	700	778	1,103	1,200	1,200	1,200
Pineapples	6,500	6,050	6,000	7,000	7,000	7,000	6,064	8,195	9,170
Strawberries	0	70	70	50	80	100	150	150	150
Coffee	105,000	115,000	105,000	106,000	105,000	108,966	108,000	108,000	108,000
Cocoa	17,600	17,420	15,000	13,500	12,000	12,000	12,000	12,000	2,200
Spices	0	2,020	2,000	3500	3,820	3,925	4,200	4,500	10,170
Other Crops	161,330	165,420	160,160	148,080	129,340	129,570	122,630	118,730	127,290
TOTAL	**411,600**	**439,270**	**458,110**	**459,900**	**447,030**	**465,100**	**465,220**	**456,140**	**458,180**

Table 2 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Cassava	21,349	26,330	18,400	29,000	25,866	23,506	19,666	20,000
Potatoes	3,413	3,146	3,372	3,364	3,316	3,187	3,128	3,074
Yams	1,005	2,005	951	1,428	1,870	1,001	1,541	3,595
Sugar Cane	46,000	46,000	47,200	48,000	47,000	49,000	49,300	49,200
Coconuts	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Oil Palm Fruit	26,455	48,508	49,175	49,175	50,980	51,700	55,500	58,199
Macadamia	2,746	2,088	3,490	3,490	3,996	2,420	1,415	1,415
Cabbages	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300
Ginger	1,640	110	361	497	354	187	110	264
Onions	572	895	628	1,200	1,020	992	1,348	1,243
Tomatoes	1,272	1,030	1,044	1,413	1,482	1,175	1,000	832
Pepper	130	104	193	133	145	155	120	84
Avocados	4,500	4,500	4,500	4,500	4,500	5,000	5,000	5,000
Bananas & Plantains	54,968	58,934	56,329	53,927	53,982	52,307	52,756	48,137
Berries	50	50	50	50	50	50	50	50
Grapefruit	0	2,050	2,095	2,100	2,100	2,100	2,100	2,100
Lemons, Limes	0	80	387	400	400	800	800	800
Mango	7,492	8,100	8,200	8,200	8,200	8,200	8,200	8,200
Melons & Watermelons	7,910	7,920	7,185	7,598	8,500	10,405	10,770	11,200
Oranges, Mandarins	25,000	25,200	25,300	26,000	26,000	27,000	25,000	26,000
Papayas	707	682	619	732	701	645	729	596
Pineapples	9,300	9,900	12,500	13,035	15,500	16,445	18,000	26,821
Strawberries	150	50	150	100	100	112	60	60
Coffee	106,000	106,000	106,000	113,130	113,130	113,130	113,130	113,130
Cocoa Beans	2,000	3,630	3,550	3,550	3,550	3,550	3,550	3,550
Spices	12,500	11,000	9,385	9,385	8,500	8,500	8,900	8,900
Other Crops	115,990	125,090	118,730	98,170	88,150	83,770	84,960	85,650
TOTAL	**455,440**	**498,700**	**485,090**	**483,880**	**474,690**	**470,640**	**472,430**	**480,340**

Appendix 2 table 3: Costa Rica Water Inputs (1000s cubic meters)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Cassava	33,480	25,880	192,510	164,610	130,014	167,679	198,090	131,130	108,698
Potatoes	15,216	11,286	12,423	14,747	12,007	9,858	9,942	12,568	12,270
Yams	1,272	1,060	2,756	2,632	5,766	4,952	3,127	1,780	3,411
Sugar Cane	362,610	402,390	432,990	465,120	486,540	489,600	556,920	512,550	593,640
Coconuts	79,240	79,814	80,388	81,824	45,936	45,936	45,936	45,936	45,936
Oil Palm Fruit	190,489	251,778	272,057	270,166	275,548	359,271	370,930	319,454	370,173
Cabbages	6,316	6,371	6,439	6,508	6,576	6,645	6,713	6,713	6,713
Ginger	892	1,115	1,115	1,115	2,034	4,638	9,214	5,349	6,929
Onions	5,263	5,586	7,056	7,767	8,870	9,804	5,584	5,664	4,466
Tomatoes	1,615	1,710	1,986	1,684	1,646	1,595	1,581	1,601	1,910
Pepper	4,992	4,990	14,126	13,119	13,483	3,798	3,870	3,870	3,870
Avocados	44,220	46,230	46,230	46,632	46,833	47,034	47,235	48,240	48,240
Bananas & Plantains	487,800	560,500	559,683	623,507	649,929	647,805	742,869	776,311	745,719
Berries	612	561	255	204	204	204	204	204	204
Grapefruit	0	0	0	0	0	0	0	0	0
Lemons, Limes	0	0	0	0	0	0	0	0	0
Mango	40,299	46,056	70,523	79,890	84,524	87,034	95,365	117,875	65,826
Melons & Watermelons	6,609	9,642	10,473	15,963	16,653	21,615	19,650	21,615	25,817
Oranges, Mandarins	55,776	74,384	89,376	90,048	107,520	87,073	100,800	110,880	200,581
Papayas	6,602	4,306	6,424	5,502	11,204	15,894	14,672	14,672	14,672
Pineapples	33,670	31,339	31,080	36,260	36,260	36,260	31,412	42,450	47,502
Strawberries	0	1,020	729	583	583	729	875	875	875
Coffee	1,499,978	1,443,609	1,509,532	1,605,072	1,499,281	1,413,973	1,433,683	1,472,568	1,261,271
Cocoa Beans	193,888	158,925	154,384	136,221	127,140	90,814	90,814	90,814	36,326
Other crops	766,473	876,015	831,832	791,577	703,356	787,552	705,428	757,742	753,542
TOTAL	**3,837,312**	**4,044,567**	**4,334,368**	**4,460,750**	**4,271,908**	**4,339,763**	**4,494,912**	**4,500,859**	**4,358,589**

Table 3 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Cassava	178,697	220,410	154,008	242,730	216,504	196,751	164,610	167,400
Potatoes	18,125	15,699	17,775	20,337	19,787	18,623	18,240	18,240
Yams	7,324	2,767	3,785	4,240	4,240	4,240	4,240	4,240
Sugar Cane	592,110	544,680	550,800	561,510	561,510	636,480	603,585	603,585
Coconuts	45,936	50,243	50,243	51,678	54,549	55,985	55,985	55,985
Oil Palm Fruit	336,108	372,444	461,102	504,226	524,145	651,020	817,560	840,270
Cabbages	6,576	6,576	6,576	6,576	6,576	6,576	6,576	6,576
Ginger	9,506	546	1,689	1,857	1,784	1,784	1,784	1,784
Onions	4,642	7,443	5,344	11,388	9,828	9,130	11,511	11,511
Tomatoes	6,018	3,639	5,191	9,452	10,560	8,930	9,500	9,500
Pepper	1,940	2,018	1,895	1,704	1,767	1,767	1,767	1,767
Avocados	46,230	46,230	48,240	48,240	48,240	50,250	50,250	50,250
Bananas & Plantains	810,227	789,403	731,437	695,815	671,089	665,066	725,930	725,930
Berries	204	204	204	204	204	204	204	204
Grapefruit	0	30,240	33,784	33,869	33,869	33,869	33,869	33,869
Lemons, Limes	0	951	4,388	9,510	9,510	15,216	15,216	15,216
Mango	46,494	75,641	188,830	184,224	207,252	207,252	207,252	207,252
Melons & Watermelons	29,287	32,325	35,464	37,335	37,597	42,182	38,252	38,252
Oranges, Mandarins	221,378	190,307	272,160	293,371	246,624	246,624	246,624	246,624
Papayas	4,130	8,697	7,542	7,137	6,932	6,932	6,932	6,932
Pineapples	48,174	63,490	66,831	70,330	73,408	81,400	53,667	53,667
Strawberries	875	350	350	350	1,842	1,842	1,842	1,842
Coffee	1,455,886	1,412,731	1,541,968	1,435,861	1,345,910	1,263,602	1,203,804	1,203,804
Cocoa Beans	38,551	40,321	32,148	32,148	32,148	32,148	32,148	32,148
Other crops	705,442	868,476	846,522	667,608	564,326	642,004	685,041	608,151
TOTAL	**4,613,859**	**4,785,829**	**5,068,275**	**4,931,698**	**4,690,201**	**4,879,876**	**4,996,389**	**4,944,999**

Appendix 2 table 4: Costa-Rica Fertilizer Inputs (metric tons/year)

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
107,000	109,000	116,000	123,000	108,000	129,000	122,000	149,000	191,000	199,000	184,000	172,000	114,000	135,000	135,000	152,000

Appendix 2 table 5: Costa Rica Pesticide Inputs (metric tons/active ingredients)

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Fungicides	1,570	1,570	1,430	770	10,760	5,710	5,080	4,120	6,340
Herbicides	1,635	1,635	4,670	7,110	1,250	2,390	5,720	9,060	4,230
Insecticides	6,115	6,115	1,710	6,870	7,400	1,500	1,970	2,380	1,510
TOTAL	**9,320**	**9,320**	**7,810**	**14,750**	**19,410**	**9,600**	**12,770**	**15,560**	**12,080**

Appendix 2 table 6: Costa Rica Agricultural Exports by Commodity (fresh or raw equivalent weight – metric tons/year)

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Cassava	39,093	40,000	69,343	61,045	56,263	98,353	112,075	131,645
Potatoes	337	0	1,139	204	140	1,654	933	1,025
Yams	4,400	4,000	12,000	12,000	11,000	14,000	14,321	8,300
Sugar	545,386	815,594	892,874	1,056,497	704,456	901,442	1,460,648	1,130,570
Coconuts	3,305	3,000	3,026	2,048	1,784	2,014	1,924	2,156
Oil Palm Fruit	86,345	23,715	93,705	127,870	176,200	173,515	202,895	296,750
Asparagus	0	0	0	0	0	65	84	47
Cabbages	0	0	0	0	0	1,026	603	2,184
Carrots & Turnips	0	0	0	0	0	247	903	905
Cauliflower & Broccoli	0	0	0	0	0	69	184	232
Ginger	0	0	0	0	0	2,366	4,217	10,439
Lettuce	0	0	0	0	0	24	31	1,032
Onions	1,337	1,000	453	1,327	586	3,316	5,005	1,247
Tomatoes	100	820	439	156	174	158	118	210
Pepper	2,853	2,853	8,664	7,822	8,014	497	431	169
Avocados	0	0	0	0	0	0	35	58
Bananas & Plantains	1,434,494	1,538,991	1,730,664	1,869,920	1,868,894	1,891,050	2,038,411	2,123,777
Lemons, Limes	369	350	399	296	356	227	142	112
Mango	0	0	266	769	878	2,053	2,500	3,678
Melons & Watermelons	22,076	36,000	39,842	60,548	74,761	113,820	99,431	110,065
Oranges, Mandarins	14,703	57,420	67,355	59,586	71,810	40,754	87,326	125,067
Papayas	1,939	2,054	2,606	1,010	938	1,442	522	1,911
Pineapples	100,225	95,880	100,286	93,491	97,061	252,799	268,682	270,943
Coffee	139,880	144,707	110,954	104,240	132,565	132,540	128,727	156,904
Cocoa	1,808	2,038	1,333	800	873	1,411	2,254	1,989
Spices	110	120	200	268	161	1,479	1,568	1,827
Other crops	653	3,232	69	830	8,801	784	8,618	8,040
TOTAL	**2,399,413**	**2,771,775**	**3,135,617**	**3,460,727**	**3,215,818**	**3,637,298**	**4,443,445**	**4,410,604**

Table 6 (continued)

	1997	1998	1999	2000	2001	2002	2003	2004
Cassava	132,025	132,280	140,490	146,537	160,050	180,743	187,955	191,960
Potatoes	967	1,377	780	291	489	542	778	598
Yams	16,000	19,825	19,179	17,883	16,803	20,000	20,000	20,000
Sugar	1,003,193	1,544,737	1,486,645	1,391,542	1,479,630	1,365,902	1,148,080	2,204,254
Coconuts	2,757	1,709	2,194	2,028	1,972	2,055	2,352	2,091
Oil Palm Fruit	354,190	231,295	399,890	479,705	388,355	390,510	534,895	897,750
Cabbages	933	1,321	2,563	1,011	2,230	2,624	2,345	1,786
Carrots & Turnips	887	1,644	3,326	3,211	4,539	5,598	4,998	7,014
Cauliflower & Broccoli	88	182	222	194	239	189	356	349
Ginger	11,229	7,842	4,054	1,856	2,739	2,787	923	1,287
Lettuce	20	541	268	163	399	76	90	153
Onions	1,892	1,728	1,252	854	3,212	3,691	2,141	2,671
Tomatoes	123	711	446	254	506	520	881	525
Pepper	143	189	116	156	85	61	64	95
Avocados	71	20	20	34	22	35	26	12
Bananas & Plantains	2,049,725	2,228,497	2,259,126	2,091,838	1,980,042	1,802,519	2,064,120	2,044,923
Grapefruit	0	0	11,682	14,817	10,014	3,463	0	9
Lemons, Limes	78	139	363	124	118	9	52	51
Mango	4,398	3,028	4,568	4,920	3,092	3,645	4,381	6,169
Melons & Watermelons	127,623	143,449	160,472	190,387	206,444	207,266	242,483	254,899
Oranges	187,283	270,862	201,385	372,334	267,111	344,437	247,554	369,676
Papayas	2,216	1,727	1,206	723	451	473	480	579
Pineapples	373,257	375,912	426,075	451,343	535,119	638,792	776,515	1,082,587
Coffee	129,310	134,782	135,982	137,304	131,159	119,883	123,055	109,030
Cocoa	1,775	1,194	268	305	522	750	575	1,203
Spices	1,885	2,137	1,810	1,439	1,353	2,307	2,402	2,483
Other crops	14,113	13,501	12,306	6,381	13,010	4,849	4,060	5,564
TOTAL	**4,421,945**	**5,121,396**	**5,278,755**	**5,317,808**	**5,210,931**	**5,105,740**	**5,371,708**	**7,208,144**

Appendix 2 table 7: Costa Rica Agricultural Crop land Devoted to Export by Commodity (ha/year)

	1989	1990	1991	1992	1993	1994	1995	1996
Cassava	2,802	2,667	4,623	4,068	3,751	6,557	7,470	8,776
Potatoes	16	0	48	8	6	78	47	47
Yams	342	333	960	831	688	875	716	461
Sugar	9,205	9,148	11,674	13,206	8,573	11,212	17,187	14,478
Coconuts	479	486	481	359	390	378	361	404
Oil Palm Fruit	6,863	1,653	6,229	8,814	12,876	9,744	11,673	19,154
Cabbages	0	0	0	0	0	135	80	290
Ginger	0	0	0	0	0	137	211	803
Lettuce	0	0	0	0	0	0	0	0
Onions	52	46	14	66	17	71	227	50
Tomatoes	3	23	11	4	4	4	3	5
Pepper	1,640	1,640	2,888	1,795	2,004	124	97	38
Avocados	0	0	0	0	0	0	7	11
Bananas & Plantains	23,455	28,141	33,607	37,125	46,156	49,836	46,232	46,015
Berries	0	0	0	0	0	0	0	0
Grapefruit	0	0	0	0	0	0	0	0
Lemons, Limes	0	0	0	0	0	0	0	0
Mango	0	0	103	371	400	925	1,177	1,427
Melons & Watermelons	1,015	1,759	2,154	2,931	3,619	4,182	3,974	4,374
Oranges, Mandarins	1,215	5,580	6,617	7,115	8,079	6,998	13,099	17,813
Papayas	65	65	65	34	17	26	11	41
Pineapples	1,432	1,370	1,433	1,336	1,387	3,611	3,838	3,871
Strawberries	0	0	0	0	0	2	6	3
Coffee	93,553	110,135	73,733	65,771	88,702	97,585	92,643	109,946
Cocoa Beans	7,453	10,144	5,880	3,600	3,742	8,464	13,521	11,932
Other crops	1,067	5,701	43	287	11,702	299	7,425	2,778
TOTAL	**150,654**	**178,893**	**150,562**	**147,720**	**192,112**	**201,244**	**220,003**	**242,716**

Table 7 (continued)

	1997	1998	1999	2000	2001	2002	2003	2004
Cassava	8,801	8,818	9,365	9,769	10,670	12,049	12,530	12,797
Potatoes	40	59	36	13	18	21	31	24
Yams	888	1,238	1,113	1,303	1,344	1,500	1,500	1,500
Sugar	11,428	18,361	19,209	18,245	19,352	17,492	13,523	27,379
Coconuts	517	320	501	464	438	433	482	429
Oil Palm Fruit	19,257	13,781	30,079	25,930	20,879	21,339	23,635	48,213
Cabbages	124	179	347	137	302	355	318	242
Ginger	864	603	364	177	327	265	88	122
Lettuce	0	0	0	0	0	0	0	0
Onions	106	74	52	35	117	133	81	96
Tomatoes	3	29	24	10	14	14	22	11
Pepper	32	49	21	81	44	31	32	48
Avocados	13	4	4	6	4	7	5	2
Bananas & Plantains	43,838	41,867	45,583	44,700	41,296	37,090	42,540	42,096
Berries	0	0	0	0	0	0	0	0
Grapefruit	0	0	1,497	1,737	1,173	406	0	1
Lemons, Limes	0	0	29	10	5	0	3	3
Mango	2,874	2,809	2,816	1,230	792	830	998	1,405
Melons & Watermelons	5,482	4,804	5,869	7,539	6,624	6,909	6,928	8,299
Oranges, Mandarins	14,745	20,555	17,920	23,259	15,908	24,401	18,212	27,197
Papayas	47	77	25	16	12	13	13	15
Pineapples	5,332	5,370	6,083	6,247	7,339	9,981	11,609	25,974
Strawberries	4	5	2	2	7	2	1	2
Coffee	105,784	93,755	97,478	90,177	98,727	96,276	105,256	97,890
Cocoa Beans	4,882	2,813	1,095	1,530	2,618	3,761	2,884	6,033
Other crops	5,587	8,453	3,664	2,693	4,168	1,743	1,283	2,176
TOTAL	**230,649**	**224,024**	**243,176**	**235,309**	**232,180**	**235,050**	**241,973**	**301,953**

Appendix 2 table 8: Costa Rica Pasture Land Devoted to Export (ha/year)

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
675,899	597,171	706,806	669,384	569,191	451,115	422,103	375,047	246,162	253,524	290,522	238,158	169,759	164,721	190,240	175,802

Appendix 2 table 9: Costa Rica Agricultural Export by Major Destination (metric tons/year)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
U.S	1,626,189	1,522,616	2,707,912	2,237,135	2,461,855	2,733,610	2,745,519	2,030,106	1,844,905	2,235,815	2,974,595
E.U	1,216,512	1,177,912	1,445,283	1,170,659	1,093,878	1,242,961	1,094,019	1,040,358	1,166,429	1,200,013	1,522,012
Canada	4,387	4,883	19,052	151,040	9,958	384,381	185,505	339,638	700,399	520,697	542,330
Central America	291,714	165,944	1,992,176	479,442	379,705	424,609	517,946	519,985	477,809	722,225	1,339,405
Other countries	440,451	1,379,357	0	261,524	1,026,168	567,699	635,784	1,208,649	739,845	616,415	656,113

Appendix 2 table 10: Costa Rica Agricultural ‘Exported Land’ by Major Destination (hectares)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
U.S	56,066	58,162	132,115	85,758	87,405	101,044	98,170	94,553	99,120	105,390	116,351
E.U	95,971	84,588	111,980	79,576	65,862	68,922	63,368	63,366	62,828	63,725	73,536
Canada	2,096	1,645	3,020	6,020	4,958	8,556	5,735	8,746	12,700	9,712	10,106
Central America	13,975	10,499	79,837	22,519	21,368	25,808	27,492	25,421	23,168	30,266	42,817
Other countries	22,359	37,462	0	23,181	25,605	25,145	30,429	31,668	24,810	29,094	32,484

Appendix 3 table 1: Canada Agricultural Production (fresh or raw equivalent weight – metric tons/year)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Wheat	24,796,208	32,098,000	31,945,600	29,877,200	27,255,900	22,919,500	24,989,400	29,801,400	24,280,300
Barley	11,784,000	13,441,400	11,617,000	11,031,500	12,972,100	11,692,000	13,032,500	15,562,000	13,527,000
Maize	6,570,900	7,066,600	7,412,500	4,882,600	6,755,200	7,189,900	7,280,900	7,541,700	7,179,800
Fodder corn	6,700,500	7,018,600	5,536,600	5,273,800	5,248,800	4,743,800	4,995,700	5,375,400	5,466,600
Rye	806,400	599,000	338,700	281,100	318,600	399,700	309,600	309,400	320,000
Oats	3,265,000	2,692,000	1,793,900	2,828,500	3,556,800	3,640,000	2,872,800	4,361,000	3,484,700
Linseed (Flax seed)	497,900	889,000	635,000	337,000	627,400	960,100	1,105,000	851,000	895,400
Mixed Grain	730,000	704,000	623,000	609,000	712,000	629,500	653,300	581,900	602,800
Potatoes	2,876,400	3,004,400	2,829,373	3,607,400	3,315,800	3,676,600	3,834,000	4,084,600	4,171,000
Sugar Beet	828,000	941,700	1,085,000	775,700	782,900	1,091,300	1,026,900	1,034,200	635,000
Beans	135,500	154,540	190,970	177,890	173,660	224,660	253,210	181,310	209,280
Peas	305,808	339,980	476,010	577,990	1,028,270	1,502,790	1,521,070	1,238,820	1,836,830
Chickpeas	0	0	0	3,000	1,000	1,000	1,000	4,000	14,500
Lentils	96,200	213,200	342,800	349,000	348,700	450,400	432,000	402,500	378,800
Buckwheat	18,800	30,700	23,300	10,750	7,600	12,400	21,200	22,200	16,500
Soybeans	1,218,700	1,262,000	1,460,000	1,455,300	1,851,300	2,250,700	2,293,000	2,170,000	2,737,700
Sunflower seed	68,200	110,300	134,600	64,800	78,500	117,000	66,200	54,900	65,100
Rapeseed	3,364,800	3,515,500	4,345,300	4,005,700	5,695,400	7,552,300	6,680,700	5,292,800	6,636,500
Canary seed	115,500	172,300	100,300	124,100	127,800	240,400	154,600	284,600	115,000
Asparagus	3,440	3,184	2,810	3,210	2,890	2,640	2,990	2,440	2,080
Cabbages	148,940	157,830	125,670	166,530	163,660	170,020	176,700	181,330	166,530
Carrots	265,720	309,230	292,000	293,850	293,830	332,760	288,710	320,400	290,510
Cauliflower	35,160	40,060	35,100	39,700	33,690	40,290	39,310	37,150	38,530
Cucumbers	96,300	121,768	77,970	86,890	89,690	96,260	99,400	114,530	116,610
Lettuce	57,520	60,330	64,880	69,930	64,450	78,250	70,610	71,450	105,140
Pepper	19,898	22,490	25,290	19,920	28,480	32,350	35,050	36,550	42,000
Pumpkin	0	0	0	0	12,290	38,630	43,690	42,130	36,310
Mushrooms	52,170	52,240	53,020	53,700	54,670	56,610	62,690	59,410	68,020
Onions	139,040	135,370	131,210	127,510	158,740	130,090	175,060	182,810	165,190
Spinach	3,083	2,975	2,990	2,510	2,660	2,450	2,760	2,880	2,580
Tomatoes	628,890	673,745	493,830	473,850	578,140	639,220	647,160	636,970	587,970
Apples	536,630	541,250	513,270	564,090	483,540	553,745	598,910	512,990	503,550

Table 1 (continued)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Apricots	269	1,956	620	1,100	1,000	1,480	1,760	1,120	1,830
Blueberries	27,525	36,114	35,860	38,960	39,670	40,640	42,980	49,090	43,500
Cherries	6,268	3,828	4,382	2,566	2,934	5,716	6,520	4,082	4,300
Cranberries	11,236	16,391	17,690	20,110	15,630	25,360	24,620	22,990	24,960
Grapes	51,015	55,936	56,650	54,670	42,270	49,180	57,320	57,840	55,560
Melons	1,740	1,250	0	0	5,450	7,540	7,090	6,230	8,690
Peaches & Nectarines	39,516	46,666	33,850	40,170	39,130	44,160	47,130	41,010	29,990
Pears	21,272	18,464	18,440	21,150	18,030	14,810	15,230	17,420	17,310
Plums	4,513	3,697	4,640	3,150	2,900	3,680	5,270	5,220	3,770
Raspberries	21,746	14,213	13,159	15,179	15,970	18,903	20,000	15,077	17,173
Strawberries	25,750	28,931	24,940	29,460	29,740	31,780	35,040	27,900	26,190
Watermelons	0	0	0	0	0	0	0	1,390	1,620
Tobacco	75,573	63,057	78,704	65,640	77,476	70,140	74,219	70,151	76,204
Tame Hay	30,000,800	32,621,900	29,192,400	27,694,600	29,703,700	31,141,000	26,851,000	28,025,000	21,138,000
TOTAL	**96,521,530**	**109,396,895**	**102,324,428**	**96,226,075**	**102,897,360**	**103,039,854**	**101,022,499**	**109,754,890**	**96,213,127**

Table 1 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	9	26,940,800	26,535,500	20,630,200	16,197,500	23,552,000	25,860,400	25,546,900
Barley	12,708,700	13,196,000	13,228,600	10,845,600	7,489,400	12,327,600	13,186,400	12,132,500
Maize	8,952,400	9,161,300	6,953,700	8,389,200	8,998,800	9,587,300	8,836,800	9,460,800
Fodder corn	6,425,600	6,611,500	5,890,300	6,079,000	6,355,800	7,213,000	7,908,700	7,469,000
Rye	408,200	386,600	260,300	227,800	133,800	327,100	417,900	366,900
Oats	3,957,500	3,641,300	3,403,300	2,690,700	2,910,700	3,691,000	3,683,100	3,333,800
Linseed (Flax seed)	1,080,900	935,000	693,400	715,000	679,400	754,400	516,900	1,035,300
Mixed Grain	548,000	446,800	382,100	446,500	358,900	384,400	318,000	291,500
Potatoes	4,329,000	4,268,000	4,567,330	4,220,430	4,705,130	5,282,420	5,170,790	4,850,000
Sugar Beet	880,000	743,900	821,000	544,300	344,700	680,400	743,900	720,000
Beans	254,182	348,044	332,154	340,018	471,586	418,664	291,403	353,100
Peas	2,404,883	2,321,646	2,940,206	2,096,771	1,423,691	2,200,656	3,405,314	3,233,370
Chickpeas	50,900	187,200	387,500	455,000	156,500	67,600	51,200	97,600
Lentils	479,800	723,800	914,100	566,300	353,800	519,900	962,000	1,187,600
Buckwheat	14,800	12,500	13,600	16,300	12,200	9,900	1,500	1,000
Soybeans	2,736,600	2,780,900	2,703,000	1,635,200	2,335,700	2,268,300	3,048,000	2,998,800
Sunflower seed	111,800	121,900	119,300	103,800	157,400	150,300	54,400	90,700
Rapeseed	7,881,900	9,104,700	7,407,500	5,121,900	4,561,400	6,997,300	8,033,600	8,657,300
Canary seed	235,300	166,000	170,800	113,900	175,700	226,400	300,500	228,000
Asparagus	2,268	2,383	2,717	2,730	2,919	3,078	3,329	3,210
Cabbages	176,920	173,500	164,710	159,830	159,023	178,504	198,018	203,040
Carrots	324,842	294,183	261,284	279,050	286,496	313,344	293,810	301,450
Cauliflower	41,092	45,443	39,085	42,643	38,324	38,719	42,651	39,790
Cucumbers	148,770	164,070	175,610	186,086	170,337	178,122	186,514	174,190
Lettuce	89,805	81,508	62,858	85,039	77,992	73,899	76,959	92,370
Pepper	43,500	44,880	48,450	54,020	40,247	37,156	36,777	43,460
Pumpkin	34,401	46,069	36,376	43,561	47,444	58,877	59,647	67,570
Mushrooms	72,880	69,280	80,241	86,357	75,075	87,937	84,682	85,000
Onions	160,600	179,560	189,350	195,498	168,228	172,388	190,273	206,620
Spinach	3,167	3,799	3,418	4,524	3,520	4,894	4,479	5,000
Tomatoes	659,500	682,590	701,330	670,262	791,951	717,385	805,091	861,750
Apples	489,018	632,386	542,570	465,418	381,859	379,192	370,338	369,500

Table 1 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Apricots	830	770	1,670	1,785	982	1,220	1,250	1,210
Blueberries	35,118	63,794	59,035	67,708	64,861	78,608	79,161	81,900
Cherries	5,275	4,475	4,437	6,539	5,532	8,117	7,951	8,400
Cranberries	36,180	35,680	31,810	34,784	51,562	52,651	66,503	67,340
Grapes	60,130	76,306	63,748	66,937	67,102	54,760	78,120	76,460
Melons	6,700	10,270	8,500	10,710	13,160	9,550	11,860	12,000
Peaches & Nectarines	31,730	32,690	33,280	35,100	28,817	29,220	29,758	29,520
Pears	19,820	19,860	16,318	13,585	14,917	15,232	14,445	14,290
Plums	3,860	3,510	2,990	2,920	2,876	3,470	3,257	3,020
Raspberries	15,451	15,650	16,247	11,658	14,880	14,236	13,828	12,920
Strawberries	26,805	26,620	23,810	23,740	25,068	24,521	24,619	23,340
Watermelons	1,190	2,010	1,580	1,710	2,760	3,040	4,240	4,200
Tobacco	73,178	70,215	53,010	58,606	54,550	46,338	42,430	43,000
Tame Hay	21,825,000	25,033,000	23,922,000	20,374,000	18,141,000	22,336,000	25,614,500	26,629,400
TOTAL	**102,043,995**	**110,038,091**	**104,396,124**	**88,331,419**	**78,719,689**	**101,739,398**	**111,202,097**	**111,616,820**

Appendix 3 table 2: Canada Land Required for Each Crop (hectares / year)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Wheat	13,717,500	14,097,500	14,160,900	13,830,300	12,374,000	10,773,000	11,122,700	12,262,000	11,409,900
Barley	4,727,000	4,528,700	4,217,000	3,792,000	4,159,000	4,092,000	4,363,000	4,888,000	4,700,000
Maize	1,034,600	1,029,800	1,104,804	8,577,700	1,012,300	973,200	1,003,500	1,090,400	1,045,100
Fodder corn	224,400	203,300	193,902	203,300	179,600	163,500	170,700	188,600	202,500
Rye	454,500	341,100	180,700	144,200	161,100	186,100	162,000	161,700	162,000
Oats	1,581,000	1,154,000	841,800	1,242,700	1,343,000	1,492,000	1,211,000	1,684,000	1,498,500
Linseed (Flax seed)	596,900	694,000	499,000	252,900	505,800	720,300	860,000	575,000	736,500
Mixed Grain	264,900	247,000	245,700	199,100	253,700	234,300	236,300	212,000	218,300
Potatoes	114,500	119,700	118,735	123,793	124,890	132,900	144,150	147,300	152,100
Sugar Beet	22,600	24,100	24,875	22,660	22,260	25,500	24,700	23,350	14,160
Beans	59,739	64,011	104,935	74,871	90,305	89,498	117,894	93,638	98,783
Peas	167,409	142,354	217,438	276,807	479,474	697,978	806,418	535,982	866,060
Chickpeas	0	0	0	2,100	700	700	770	3,100	10,400
Lentils	103,100	133,600	238,170	267,100	327,800	386,400	327,000	303,500	329,000
Buckwheat	22,400	27,500	21,800	17,200	9,400	10,700	16,800	17,100	15,000
Soybeans	539,500	483,600	598,000	622,900	719,600	820,100	824,000	856,200	1,059,600
Sunflower seed	55,400	66,800	84,100	53,000	79,000	85,000	46,500	36,000	51,600
Rapeseed	3,117,900	2,759,700	3,253,377	3,155,500	4,289,700	6,089,200	5,534,000	3,684,000	5,162,200
Canary seed	119,400	121,000	95,165	92,000	123,000	204,300	145,600	234,700	113,300
Asparagus	1,984	1,797	1,642	1,623	1,530	1,493	1,181	1,199	1,267
Cabbages	5,873	5,556	4,500	8,600	8,600	8,800	8,500	9,211	8,812
Carrots	7,561	7,001	7,240	7,311	7,761	7,789	8,600	8,928	8,877
Cauliflower	2,681	2,865	2,802	2,719	2,625	2,707	2,870	2,743	2,732
Cucumbers	3,423	3,064	2,725	2,727	2,712	2,773	2,853	3,058	2,918
Lettuce	2,791	2,613	2,705	2,774	2,523	2,916	3,577	3,270	3,142
Pepper	2,019	2,036	2,011	2,036	1,807	1,826	2,182	2,319	2,167
Pumpkin	0	0	0	0	1,080	1,200	1,360	1,854	1,517
Onions	4,062	4,265	4,281	4,292	4,281	4,600	4,987	4,804	4,454
Spinach	370	417	402	431	428	447	502	526	457
Tomatoes	15,540	14,272	11,820	11,274	11,233	11,459	11,312	10,303	9,373
Apples	31,570	32,887	32,636	32,145	32,777	33,286	31,369	29,359	27,905
Apricots	54	390	120	247	244	229	239	276	200

Table 2 (continued)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Blueberries	14,063	13,741	15,100	18,231	19,492	17,943	18,250	19,888	20,048
Cherries	1,048	1,014	1,050	1,029	1,068	1,074	1,064	986	767
Cranberries	983	997	995	1,033	1,054	1,072	1,616	1,443	1,655
Grapes	7,273	6,442	5,762	6,206	6,326	6,526	7,177	6,970	7,017
Melons	75	50	0	0	70	73	70	60	80
Peaches & Nectarines	4,063	4,085	4,015	4,027	4,021	3,821	3,755	3,322	3,179
Pears	2,185	2,171	2,155	2,163	2,161	2,232	2,136	1,969	1,754
Plums	947	817	1,053	1,051	931	1,070	947	845	714
Raspberries	3,433	3,455	3,446	3,414	3,385	3,407	3,190	3,495	3,452
Strawberries	4,977	4,958	5,228	5,190	5,277	5,541	5,709	5,370	5,032
Watermelons	0	0	0	0	0	0	0	75	90
Tobacco	30,600	29,342	30,374	26,651	31,469	26,080	26,893	25,701	28,108
Tame Hay	5,781,800	5,903,900	6,029,706	6,029,706	6,514,700	6,739,000	6,578,000	6,396,000	6,350,000
TOTAL	**32,852,123**	**32,285,900**	**32,372,169**	**39,125,011**	**32,922,184**	**34,064,040**	**33,845,371**	**33,540,544**	**34,340,720**

Table 2 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Wheat	10,679,700	10,374,800	10,854,800	10,605,500	8,836,000	10,467,400	9,862,400	9,830,900
Barley	4,272,000	4,069,300	4,449,900	4,149,500	3,347,900	4,445,700	4,049,600	3,879,800
Maize	1,118,300	1,148,800	1,106,500	1,267,500	1,283,200	1,226,100	1,072,300	1,095,800
Fodder corn	199,700	186,600	202,600	219,700	219,800	223,800	222,200	205,100
Rye	207,600	168,700	114,500	123,000	76,800	147,300	164,900	156,500
Oats	1,591,600	1,398,400	1,299,000	1,238,400	1,378,900	1,574,700	1,315,200	1,342,000
Linseed (Flax seed)	857,900	707,000	590,900	661,700	633,400	728,400	528,100	811,400
Mixed Grain	197,800	153,200	128,300	159,200	131,800	135,400	110,800	108,300
Potatoes	156,376	156,619	159,240	166,650	170,900	180,890	170,530	165,000
Sugar Beet	18,200	17,400	16,600	11,700	10,100	12,100	14,200	13,800
Beans	107,886	161,854	173,458	184,953	230,786	177,469	138,898	179,113
Peas	1,096,445	852,466	1,237,888	1,298,819	1,065,825	1,288,070	1,361,860	1,381,549
Chickpeas	38,400	131,500	283,200	467,400	153,700	62,700	38,500	64,700
Lentils	371,400	496,600	687,900	664,100	386,900	535,700	750,600	805,300
Buckwheat	14,400	13,200	14,800	14,300	11,900	9,300	4,000	3,000
Soybeans	980,100	1,004,000	1,060,700	1,068,900	1,023,800	1,046,600	1,177,500	1,158,300
Sunflower seed	70,000	82,900	73,600	69,200	96,200	116,500	60,600	68,800
Rapeseed	5,707,900	5,837,300	5,067,100	3,943,000	3,680,400	5,016,900	5,241,800	5,364,700
Canary seed	208,400	145,700	163,900	163,400	226,600	246,800	317,600	186,100
Asparagus	1,112	1,070	1,168	1,188	1,228	1,281	1,398	1,348
Cabbages	8,298	8,708	8,313	8,930	8,822	9,152	9,344	9,581
Carrots	8,896	8,553	7,991	8,159	8,262	9,542	8,812	9,041
Cauliflower	2,531	2,620	2,497	2,618	2,749	2,572	2,654	2,476
Cucumbers	3,220	3,884	4,395	4,700	4,903	4,618	4,373	4,084
Lettuce	3,258	3,065	3,298	3,384	3,045	2,970	3,242	3,891
Pepper	1,883	1,834	2,091	2,726	2,044	2,032	1,760	2,080
Pumpkin	2,689	3,299	3,216	4,000	3,851	4,451	4,632	5,247
Onions	4,408	4,771	4,887	5,848	5,420	5,698	5,621	6,104
Spinach	551	632	588	690	643	583	631	704
Tomatoes	8,052	8,408	7,841	8,573	9,254	8,576	8,313	8,898
Apples	26,940	26,547	25,271	23,500	20,584	21,600	20,813	20,766
Apricots	210	178	160	208	200	210	200	194

Table 2 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Blueberries	19,955	22,511	23,921	25,000	23,996	23,269	26,058	26,960
Cherries	842	865	860	1,044	1,095	1,085	1,072	1,133
Cranberries	1,888	1,945	1,947	2,382	2,547	2,829	2,851	2,887
Grapes	7,080	7,313	7,466	7,800	8,960	8,869	9,460	9,259
Melons	60	90	90	90	110	90	100	100
Peaches & Nectarines	2,693	2,683	2,622	2,600	2,758	2,893	2,829	2,806
Pears	1,637	1,386	1,297	1,250	1,344	1,261	1,137	1,125
Plums	731	577	524	524	627	647	599	556
Raspberries	3,474	3,007	2,958	3,000	3,363	3,345	3,167	2,958
Strawberries	4,961	4,397	4,269	4,000	4,684	4,478	4,237	4,016
Watermelons	70	110	120	120	180	200	200	200
Tobacco	27,666	25,266	23,800	23,724	18,939	15,994	15,700	16,000
Tame Hay	6,232,000	6,479,000	6,925,000	6,662,000	6,437,000	7,162,000	7,482,700	7,316,300
TOTAL	**34,269,212**	**33,729,058**	**34,751,476**	**33,291,080**	**29,554,919**	**34,956,274**	**34,238,566**	**34,292,876**

Appendix 3 table 3: Canada Land for Beef Production (natural pasture, seeded pasture and cropland - hectares)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Permanent Pasture	15,842,000	15,903,000	15,963,000	15,893,000	15,823,000	15,753,000	15,682,000	15,612,000	15568000
Seeded or Tame Pasture	4,140,000	4,140,000	4,140,000	4,140,000	4,140,000	4,350,000	4,350,000	4,350,000	4350000
Tame Hay	5,781,800	5,903,900	6,029,706	6,029,706	6,514,700	6,739,000	6,578,000	6,396,000	6350000
Extra Grain Feed Land	5,974,104	5,368,679	5,907,416	6,449,922	5,950,580	6,158,728	6,808,302	6,707,962	8096189.68
TOTAL	**31,737,904**	**31,315,579**	**32,040,122**	**32,512,628**	**32,428,280**	**33,000,728**	**33,418,302**	**33,065,962**	**34,364,190**

Table 3 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Permanent Pasture	15,524,000	15,480,000	15,435,000	15,391,000	15,390,000	15,390,000	15,390,000	15,390,000
Seeded or Tame Pasture	4,350,000	2,675,305	2,675,305	2,675,305	2,675,305	2,675,305	2,675,305	2,675,305
Tame Hay	6,232,000	6,479,000	6,925,000	6,662,000	6,437,000	7,162,000	7,482,700	7,316,300
Extra Grain Feed Land	7,631,881	6,931,320	7,667,898	8,989,053	10,069,749	8,630,753	7,842,786	8,275,832
TOTAL	**33,737,881**	**31,565,625**	**32,703,203**	**33,717,358**	**34,572,054**	**33,858,058**	**33,390,791**	**33,657,437**

Appendix 3 table 4: Canada Agricultural Exports by Commodity (fresh or raw equivalent weight – metric tons/year)

	1989	1990	1991	1992	1993	1994	1995	1996
Wheat	11,576,747	18,278,516	23,629,907	23,984,942	18,210,927	21,745,912	17,510,404	17,029,464
Barley	5,818,571	6,183,803	6,530,741	5,984,182	6,844,305	7,593,223	6,695,481	9,006,305
Maize	354,786	459,607	1,106,863	797,972	816,381	872,658	1,090,324	1,384,573
Rye	157,244	336,498	313,617	186,814	211,094	149,930	214,018	174,225
Oats	1,197,479	958,887	706,060	1,039,415	1,636,070	1,759,718	2,130,137	2,213,134
Linseed (Flax seed)	507,943	488,944	421,940	416,886	496,359	680,818	891,737	767,392
Potatoes	565,903	653,079	620,118	552,498	836,818	863,579	972,342	1,130,105
Beans	79,077	98,656	93,170	117,747	89,529	129,832	155,809	141,915
Peas	226,647	189,693	222,250	329,707	539,244	722,314	1,097,780	916,371
Chickpeas	78	37	43	4,688	379	320	917	546
Lentils	81,273	116,327	149,390	222,181	257,120	260,442	285,364	284,813
Buckwheat	16,369	13,501	16,733	17,234	7,685	16,185	8,796	8,625
Soybeans	228,845	175,855	259,930	260,934	440,662	602,635	715,449	694,888
Sunflower seed	23,159	30,519	56,847	93,044	63,087	36,956	78,010	41,956
Rapeseed	2,538,953	2,504,370	2,487,003	2,752,182	3,590,854	4,966,302	4,724,809	4,004,337
Canary seed	73,536	87,621	70,418	81,147	121,721	116,693	158,974	105,435
Cabbages	13,216	21,539	18,647	15,649	21,876	23,807	31,946	29,548
Carrots	6,131	40,988	48,495	47,301	42,654	62,942	71,819	66,839
Cauliflower	802	1,569	1,451	3,971	3,553	3,731	2,900	5,840
Lettuce	954	3,709	3,541	6,554	7,211	8,306	9,702	10,363
Pepper	65	1,420	2,367	2,017	3,521	3,839	6,953	6,567
Pumpkin	0	0	0	0	0	0	0	0
Mushrooms	2,997	3,626	6,317	3,509	2,266	4,111	4,220	5,498
Onions	3,858	21,795	31,078	29,310	22,956	27,234	30,285	37,899
Spinach	1	2	4	1	55	97	160	53
Tomatoes	5,028	5,022	4,009	8,767	15,724	43,892	80,672	34,756
Apples	75,699	76,929	95,366	74,359	65,901	68,879	89,940	109,708

Table 4 (continued)

	1989	1990	1991	1992	1993	1994	1995	1996
Blueberries	2,984	7,381	9,218	9,006	7,693	8,317	8,577	7,084
Cherries	96	286	242	389	250	383	198	165
Grapes	715	4,686	5,146	8,127	5,028	3,717	5,031	10,420
Melons	0	3	11	46	36	0	93	186
Peaches & Nectarines	6	3,112	267	842	201	190	234	456
Pears	655	566	319	262	682	358	787	591
Plums	12	7	19	23	18	57	44	9
Raspberries	73	5,099	4,806	6,328	5,246	6,519	6,605	4,624
Strawberries	17	110	37	4	49	56	68	436
Tame Hay	4,613,328	6,021,782	5,594,868	6,812,823	7,968,916	8,328,775	7,310,828	9,057,431
TOTAL	**28,166,148**	**36,792,128**	**42,507,369**	**43,867,636**	**42,327,236**	**49,106,816**	**44,384,524**	**47,293,995**

Table 4 (continued)

	1997	1998	1999	2000	2001	2002	2003	2004
Wheat	23,629,403	18,261,592	16,749,323	19,346,449	18,048,537	13,019,485	12,472,025	15,946,432
Barley	9,327,214	7,832,972	7,739,309	8,546,165	9,632,847	9,358,973	6,407,845	8,299,893
Maize	1,231,361	1,391,378	2,012,141	1,461,847	1,572,987	1,814,333	1,797,177	2,097,638
Rye	136,980	85,052	82,643	83,608	85,359	58,297	50,591	213,574
Oats	2,558,865	2,143,117	2,198,940	2,589,144	2,708,007	2,218,282	2,049,355	2,237,592
Linseed (Flax seed)	893,225	826,111	577,628	607,583	674,110	647,776	690,000	547,022
Potatoes	1,268,350	1,623,073	1,708,197	1,724,612	1,756,597	1,914,573	2,289,281	2,547,114
Beans	136,882	171,084	240,201	240,018	263,462	284,225	324,643	326,234
Peas	940,610	1,213,531	1,511,935	1,894,176	2,068,854	780,896	1,096,133	1,678,643
Chickpeas	864	12,310	20,580	132,799	149,212	111,573	88,580	68,265
Lentils	300,846	374,118	417,208	518,911	490,662	351,096	370,876	373,549
Buckwheat	13,936	5,041	7,099	8,988	7,363	5,385	5,240	4,645
Soybeans	670,920	1,063,002	1,068,530	954,845	744,078	648,275	974,700	1,052,653
Sunflower seed	37,935	49,518	43,460	63,242	98,911	96,193	103,632	77,615
Rapeseed	4,318,770	6,224,387	5,629,083	5,531,729	5,562,602	3,763,024	4,703,342	5,778,346
Canary seed	134,159	127,434	145,045	150,899	165,493	142,147	170,119	154,218
Cabbages	36,645	37,407	36,328	39,331	40,085	37,846	36,791	42,770
Carrots	67,230	63,785	58,440	57,600	67,434	59,997	67,471	72,536
Cauliflower	11,986	11,028	6,838	6,958	6,077	6,046	7,194	12,339
Lettuce	20,154	11,687	13,777	19,142	23,222	18,958	19,875	21,651
Pepper	10,707	16,621	22,339	26,478	35,370	41,925	46,869	49,206
Pumpkin	0	0	0	0	0	0	0	0
Mushrooms	6,731	10,052	13,371	17,590	19,056	21,991	25,113	25,814
Onions	28,797	49,025	35,663	36,787	59,911	57,384	54,985	61,384
Spinach	65	274	388	528	1,071	1,664	2,399	1,201
Tomatoes	40,761	75,218	82,123	102,761	108,955	104,693	138,254	139,737
Apples	89,285	65,009	68,143	63,846	61,432	62,775	49,179	44,218
Blueberries	6,585	7,451	12,843	13,730	18,412	15,691	18,143	19,776

Table 4 (continued)

	1997	1998	1999	2000	2001	2002	2003	2004
Cherries	204	282	233	249	1,047	1,908	2,050	3,042
Cranberries	0	0	0	26,819	26,888	40,083	43,762	44,972
Grapes	11,175	9,606	11,703	13,586	9,114	11,062	10,674	16,038
Melons	16	16	37	73	1,654	600	776	437
Peaches & Nectarines	317	268	457	590	405	204	146	126
Pears	1,366	711	700	528	429	462	178	197
Plums	18	4	24	24	15	3	7	15
Raspberries	4,232	2,978	3,935	3,516	4,090	2,168	2,745	2,985
Strawberries	95	71	189	490	298	401	258	216
Tame Hay	7,881,199	8,513,758	9,710,669	9,574,253	9,735,486	9,637,485	7,261,700	8,965,506
TOTAL	**53,880,896**	**50,275,920**	**50,217,490**	**53,852,926**	**54,243,363**	**45,332,878**	**41,375,870**	**50,923,460**

Appendix 3 table 5: Canada Agricultural Crop Land Devoted to Export by Commodity (ha/year)

	1989	1990	1991	1992	1993	1994	1995	1996
Wheat	6,404,485	8,027,808	10,474,714	11,102,598	8,267,548	10,221,345	7,793,833	7,006,856
Barley	2,334,057	2,083,491	2,370,677	2,056,985	2,194,391	2,657,482	2,241,465	2,828,880
Maize	65,709	70,666	74,125	48,826	67,552	71,899	72,809	75,417
Rye	88,623	191,616	167,316	95,832	106,737	69,806	111,987	91,055
Oats	579,865	411,045	331,328	456,665	617,758	721,285	897,921	854,591
Linseed (Flax seed)	608,971	381,689	331,583	312,860	400,160	510,780	694,013	518,508
Potatoes	22,527	26,020	26,023	18,960	31,519	31,216	36,558	40,754
Beans	43,472	49,236	63,160	58,739	49,482	57,196	77,484	85,137
Peas	144,266	88,529	107,596	169,139	259,753	342,805	596,898	406,220
Chickpeas	0	0	0	3,282	265	224	706	423
Lentils	87,100	72,896	103,794	170,045	241,700	223,440	216,005	214,759
Buckwheat	19,503	12,093	15,656	27,574	9,505	13,966	6,970	6,644
Soybeans	101,308	67,388	106,463	111,687	171,284	219,587	257,097	274,172
Sunflower seed	18,133	17,929	34,673	73,229	61,881	26,217	52,440	26,900
Rapeseed	2,307,929	1,939,268	1,848,936	2,164,346	2,689,174	3,958,790	3,870,891	2,729,982
Canary seed	76,022	61,532	66,810	60,158	117,152	99,170	149,721	86,950
Asparagus	1	1	1	3	5	15	23	9
Cabbages	521	758	668	808	1,150	1,232	1,537	1,501
Carrots	174	928	1,202	1,177	1,127	1,473	2,139	1,862
Cauliflower	61	112	116	272	277	251	212	431
Lettuce	46	161	148	260	282	310	491	474
Pepper	7	129	188	206	223	217	433	417
Onions	113	687	1,014	987	619	963	863	996
Spinach	0	0	1	0	9	18	29	10
Tomatoes	124	106	96	209	306	787	1,410	562

Table 5 (continued)

	1989	1990	1991	1992	1993	1994	1995	1996
Apples	4,453	4,674	6,064	4,237	4,467	4,140	4,711	6,279
Blueberries	1,525	2,808	3,882	4,214	3,780	3,672	3,642	2,870
Cherries	16	76	58	156	91	72	32	40
Cranberries	0	0	0	0	0	0	0	0
Grapes	102	540	523	923	752	493	630	1,256
Melons	0	0	0	0	0	0	1	2
Peaches & Nectarines	1	272	32	84	21	16	19	37
Pears	67	67	37	27	82	54	110	67
Plums	3	2	4	8	6	17	8	1
Raspberries	12	1,240	1,259	1,423	1,112	1,175	1,053	1,072
Strawberries	3	19	8	1	9	10	11	84
Tame Hay	887,178	1,094,869	1,165,598	1,584,378	1,732,373	1,810,603	1,783,129	2,058,507
TOTAL	**13,796,377**	**14,608,673**	**17,303,751**	**18,530,299**	**17,032,551**	**21,050,731**	**18,877,281**	**17,323,860**

Table 5 (continued)

	1997	1998	1999	2000	2001	2002	2003	2004
Wheat	11,104,043	8,098,267	6,449,986	7,913,953	9,278,499	7,102,441	5,543,122	6,081,550
Barley	3,240,754	2,633,020	2,386,613	2,874,786	3,685,521	4,183,716	2,310,882	2,548,951
Maize	71,798	89,524	91,613	69,537	83,892	89,988	95,873	88,368
Rye	69,346	43,255	36,063	36,777	46,090	33,462	22,783	84,273
Oats	1,100,350	861,901	844,479	988,261	1,246,379	1,050,870	874,335	799,026
Linseed (flax seed)	734,681	655,696	436,770	517,753	623,829	603,931	666,216	558,870
Potatoes	46,252	58,630	62,684	60,129	69,362	69,541	78,394	84,002
Beans	72,573	84,593	118,317	139,404	150,652	147,229	149,068	182,377
Peas	452,383	560,049	560,666	806,685	1,299,763	600,232	655,172	676,179
Chickpeas	620	9,287	14,456	97,054	153,274	109,579	82,163	51,331
Lentils	261,287	289,587	286,249	390,511	575,422	383,963	382,149	291,471
Buckwheat	12,669	4,905	7,496	9,781	6,459	5,253	4,922	12,387
Soybeans	259,674	380,704	385,779	374,699	486,389	284,157	449,730	406,665
Sunflower seed	29,485	30,473	28,130	36,472	63,654	57,815	78,946	83,610
Rapeseed	3,289,740	4,421,043	3,560,007	3,730,597	4,196,607	2,925,009	3,257,162	3,691,998
Canary seed	132,176	112,863	127,311	144,803	237,402	183,321	185,456	162,987
Asparagus	2	4	3	6	5	80	246	333
Cabbages	1,939	1,754	1,823	1,985	2,240	2,100	1,886	2,018
Carrots	2,054	1,747	1,699	1,762	1,972	1,730	2,055	2,176
Cauliflower	850	679	394	445	373	434	478	768
Lettuce	602	424	518	1,004	924	740	799	912
Pepper	552	719	913	1,143	1,785	2,129	2,563	2,355
Onions	776	1,346	948	949	1,792	1,849	1,817	1,813
Spinach	12	48	65	91	163	304	286	169
Tomatoes	650	918	1,012	1,149	1,394	1,223	1,653	1,443
Apples	4,948	3,581	2,861	2,974	3,102	3,384	2,801	2,485

Table 5 (continued)

	1997	1998	1999	2000	2001	2002	2003	2004
Apricots	1	0	4	2	1	1	1	4
Blueberries	3,035	4,234	4,532	5,563	6,798	5,805	5,371	6,510
Cherries	36	45	45	48	167	378	274	410
Cranberries	0	0	0	1,642	1,841	1,980	2,351	1,928
Grapes	1,411	1,131	1,122	1,591	1,062	1,477	1,729	1,942
Melons	0	0	0	1	14	5	7	4
Peaches & Nectarines	34	23	38	46	30	20	14	12
Pears	138	59	49	42	39	42	15	16
Plums	3	1	4	4	3	1	1	3
Raspberries	851	670	756	640	1,052	490	645	684
Strawberries	18	13	31	88	50	75	47	37
Tame Hay	2,388,242	2,432,502	2,489,915	2,735,501	3,140,479	3,441,959	2,342,484	2,423,110
TOTAL	**23,285,461**	**20,783,698**	**17,903,350**	**20,947,877**	**25,368,482**	**21,296,710**	**17,203,897**	**18,253,174**

Appendix 3 table 6: Canada Beef ‘Exported Lands’ (ha/year)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
Natural Pasture	2,658,308	3,383,717	3,476,210	4,630,033	5,142,438	5,162,023	5,077,308	6,111,722	6,647,185
Seeded pasture	694,697	880,877	901,554	1,206,087	1,345,490	1,425,430	1,408,385	1,702,920	1,857,352
Extra feed lands	1,032,065	1,271,646	1,354,586	1,902,453	2,057,269	2,195,176	2,164,559	2,573,789	2,909,620
TOTAL	**4,385,070**	**5,536,240**	**5,732,350**	**7,738,570**	**8,545,200**	**8,782,630**	**8,650,250**	**10,388,430**	**11,414,160**

Table 6 (continued)

	1998	1999	2000	2001	2002	2003	2004	2005
Natural Pasture	6,880,084	6,993,954	7,250,139	8,239,780	8,995,003	5,541,914	5,970,661	6,503,479
Seeded pasture	1,927,877	1,208,718	1,256,646	1,432,261	1,563,637	963,373	1,037,904	1,130,526
Extra feed lands	2,926,291	2,936,921	3,254,822	3,863,930	4,421,865	2,690,086	2,743,813	3,023,721
TOTAL	**11,734,250**	**11,139,590**	**11,761,610**	**13,535,970**	**14,980,500**	**9,195,370**	**9,752,380**	**10,657,730**

Appendix 3 table 7: Canada Agricultural ‘Export Lands’ by major Destination (hectares)

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
U.S	1,461,744	1,315,611	1,363,781	2,101,966	2,644,427	4,093,172	3,216,952	3,016,376	3,818,014
Europe	1,164,890	761,319	897,120	922,096	1,510,358	2,291,424	2,348,295	1,388,095	1,689,037
Asia	5,029,593	5,643,856	6,498,263	7,222,413	5,806,592	6,918,666	6,444,128	5,066,679	5,571,719
Latin America	816,379	899,349	1,340,850	1,848,181	2,052,752	2,390,831	1,612,975	2,126,627	2,218,450
Others	3,787,791	4,024,988	5,278,947	3,756,621	2,307,496	2,339,638	2,115,037	1,953,050	3,292,611

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
U.S	3,305,803	3,108,719	3,308,692	3,993,580	3,536,149	2,685,675	2,898,328	2,979,784
Europe	1,754,979	1,213,425	1,442,782	2,196,504	1,272,389	2,378,791	1,826,739	1,508,263
Asia	5,726,264	4,611,931	4,916,267	6,508,636	4,165,919	3,976,211	5,135,063	5,533,702
Latin America	2,661,069	1,880,417	2,432,612	3,257,752	2,455,896	1,940,475	2,221,450	2,271,750
Others	2,740,417	2,650,663	3,754,136	3,112,356	2,224,905	1,642,327	1,498,954	1,770,891