ECOLOGICAL IMPACTS OF CHILE'S NEOLIBERAL POLICIES, WITH SPECIAL EMPHASIS ON AGROECOSYSTEMS

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Abstract. Although Chile has been touted for developing a broad market liberalization and opening to the international economy, evidence is emerging that such neoliberal economic policies are dramatically impacting biodiversity and the natural resource base. This paper examines the evidence on the plundering of forestry and fishery resources and the damming and pollution of aquatic ecosystems. Although it may be argued that economic liberalization policies have been effective in reallocating agricultural resources toward more competitive activities, the ecological toll imposed by the expansion of export-led modern agriculture has been heavy. An effective agricultural development strategy in Chile should confront such ecological costs and should promote alternatives to high input agriculture.

Key words: Chile, environment, neoliberal policies, sustainability

1. Introduction

A military coup in 1973 brought in Chile an end to agrarian reform implemented by Allende's socialist government, which tried to modernize social relations in the country side through redistribution of land, the creation of cooperatives, and peasant unionization. The main objective of the military regime was to reverse the land distribution process and allow concentration of larger parcels to create a modern and capitalized commercial agriculture (Muñoz and Ortega, 1991). Following the coup, Chile was the first Latin American country to develop a model of broad market liberalization and opening to the international economy. The junta implemented a series of economic measures directed toward the privatization of public-sector production activities, including partial abandonment of the state's regulatory and welfare functions, decrease of public expenditure, external trade opening, attraction of foreign capital, and the liberalization of domestic prices and the financial system (Collins and Lear, 1995)

After a series of economic fluctuations that plagued the Chilean economy between 1977 and 1981, the military government reacted by applying an 'automatic adjustment' followed by a strengthening of economic liberalization, deregulation and export strategies. By liberalizing capital markets, reducing trade barriers and divesting itself from all of the country's publicly owned enterprises, the Pinochet government anticipated structural adjustment programs in other countries by at least a decade. During the 1983–1988 period, these radical

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policy reforms produced mixed results. Despite the vigorous growth of industry, a great portion of the population felt the social costs of such adjustment in the form of unemployment and widened poverty. Per capita consumption in 1987 was 22.4% lower than in 1972 and 25.1% lower than 1981 (Boswarth et al., 1994).

In 1984, Chile's economy recovered due to a boom in the export sector, which climbed from US $3.8 billion in 1983 to US $8.1 billion. The most important transformation in agriculture was the development of the fruit export sector which emerged as the most dynamic activity in the last two decades. The road of capitalist explosion in agriculture led to the success of larger farmers (fruit growers in central valley and wheat/livestock producers in the south) while doing very little for the peasant sector which was excluded from the process (Muñoz and Ortega, 1991). The performance of the Chilean economy was reinforced after Chile's return to democracy in 1990. Under the transitional governments, liberalizing policies continued but with attempts at making the model more equitable (Claude, 1997).

As globalization proceeds, Chile's celebrated economic growth is touted as the perfect model to be followed by other countries. But, is the Chilean case really a success, especially if success is to be measured by the effects of economic policies on the environment? Although environmental costs are rarely considered in neoliberal economic analysis, there is growing evidence that many productive sectors in Chile have experienced a negative environmental impact (Quiroga, 1995). This impact will most probably increase as the Chilean export model continues to be based on the massive extraction of products derived from mining, agriculture, fishing, and forestry exploitation. According to a 1993 government data, mining, fishery, forestry, and agriculture sectors jointly accounted for 85% of Chile's export trade.

There is growing evidence that Chile's economic model is dramatically affecting biodiversity in its territory by plundering its rich forestry and fishery resources, and that the expansion of modern agriculture is leaving a heavy ecological toll (Hajek et al., 1990). Although detailed data on the environmental consequences of the model are hard to obtain, herein we present relevant information to shed a light on the ecological realities in Chile with an emphasis on the agricultural sector, after more than two decades of free-market transformations. The consequences, in terms of the environment and sustainability, are not only important to Chileans but also to other countries who want to emulate the model.

2. The Chilean government and the environment

Until 1989, state involvement in environmental matters was marginal. It could be argued that throughout the authoritarian regime (1973–1989), not only was there no environmental policy, but its absence was also considered an advantage in attracting foreign capital to Chile. Systematic formulation of environmental policy began only in 1990, coinciding with the initiation of the democratic government.

During the period of consolidation of the liberal economic model, public awareness of environmental issues grew considerably due to the criticism made by non-governmental organizations and some environmentally concerned scientific groups about specific cases of environmental degradation. The persistent activism of the environmental movement begun to bear some fruit by the end of the 1980s when, under pressure, some courts of justice issued decisions in favor of environmental protection. Such cases, however, were exceptional, as government policies did nothing to prevent the overexploitation of the *concholepas* – an abalone sea resource – almost driven to extinction. Neither are policies preventing the negative environmental effects derived from the cultivation of salmon, one of the main non-traditional Chilean export products, nor the illegal use of dolphins as bait for the capture of crab, another Chilean export product (Schurman, 1996). The total failure of a variety of measures to control the grave air pollution in Santiago is another testimony of the inability of the governance system to solve environmental problems.

Environmental issues were included in the Chilean political debate after the country's return to democracy. The new administration created the Special Decontamination Commission of the Metropolitan Region, and in June of the same year, it established the National Commission on the Environment (CONAMA), along with the Regional and Provincial Commissions on the Environment and of Ministerial Environmental Units. CONAMA's activities were directed toward improving ministerial coordination on environmental matters, and developing new legal and institutional frameworks for the promotion of environmental well-being in Chile. This last goal was reached in September 1992, when the executive branch remitted an environmental bill to Congress. The government also introduced other important initiatives, outstanding among them the Fishing Law and the legislation on Native Forests and on Waters (Espinoza et al., 1994). It also introduced regulations aimed at controlling pollution in Santiago. Such environmental policies, however, have been mostly cosmetic, focusing on specific isolated problems. CONAMA has no mandate to ensure strict compliance with environmental regulations, a circumstance that many private industries and international corporations exploit to their maximum advantage.

Although there is broad concern about the environmental effects of the style of development pursued by the current Chilean government in continuity with the economic policy of the military regime, the environmental record of President Patricio Aylwin's and Eduardo Frei's democratic coalition governments (1990–1994; 1995 until today) is a matter of discussion, given the constraints imposed by a transition conducted within the institutional framework created by the military. Both governments have given priority to stabilizing the political situation and ensuring the maintenance of economic growth, rather than implementing environmental policies. Despite the inefficiency of existing policies, supporters of the model affirm that the advance of environmental matters in Chile has resulted largely from the partnership between the democratic government and the private sector. According to government supporters, the case of Chile does not suggest that economic liberalization transforms countries into havens for pollution and degradation of natural resources. On the contrary, according to them, data sector supports the proposition that trade opening tends to have positive impact on the environment (Muchnik and Errazuriz, 1998). They argue that, by increasing competitive pressures, external liberalization accelerates investment in new non-polluting technologies that are imported from countries with stricter environmental standards. However, existing evidence on air, water, and soil contamination throughout the country does not support these claims.

Santiago, the capital of Chile, is famous for being among the cities with worst air quality in the world. Although the smog in Santiago is by no means a consequence of neoliberal regimes, the condition has worsened dramatically over the last decade, with local authorities often declaring states of emergency or pre-emergency which include the provisional closing down of the worse polluting industries and limiting the circulation of motor vehicles, a positive measure annulled by the doubling of the number of cars in the last ten years. Thus, although environment may be in the rhetoric of the Chilean democratic government, the style of development associated with free trade policies that it espouses, tends to fuel the over-exploitation of resources in which the country has comparative advantages, while simultaneously under-utilizing a series of environmental resources that, if properly wielded, could improve national and regional well-being.

3. The destruction of native forests

Original Chilean native forests, estimated at close to 30 million ha, have shrunk this century to its present area of some 15 million ha. In southern Chile, about 40% of the temperate rainforest still remains largely comprised of southern beech and stands of ancient alerce (Wilcox, 1995).

These remaining pristine areas are much coveted by national and transnational forest companies. Combined exports of lumber, woodchips, pulp, etc. have already exceeded the $1.8 billion figure projected by the government for the year 2000. Today Chilean old-growth native forests are being destroyed at a rate of 120,000–200,000 ha per year, of which 60–80% are substituted with artificial tree plantations. A report from Chile's Central Bank projects states that if current trends of destruction continue, there could be virtually no mature native forest left in Chile within 20–30 years, apart from that which is protected in national parks. Most seriously affected has been the central Sixth Region where 40–60% of native forest has been cleared since 1984 (CODEFF, 1988).

Since native forests have been practically exhausted in central Chile, the frontier of exploitation has now moved much further south (Lara and Veblen, 1993). The cool beech forest of Tierra del Fuego composed of rare lenga and coigue species, are now in danger of destruction. The timber industry has priced the monkey-puzzle (*Araucaria araucana*) for its high-quality and valuable wood. This tree has been depleted throughout much of its range. Over the years, the timber industry and environmentalists have been at odds regarding the most effective way to use and manage the species. No effort has been made by industry to incorporate the knowledge of the indigenous Araucanos who, since time immemorial, have been excellent stewards of the monkey-puzzle forests (Aagesen, 1998).

Felling has soared in the last 10 years as firms clear woods for replanting with fast-growing radiata pine and eucalyptus, both imported species. Conversion of native forest to artificial plantations in south-central Chile had already reached 1.7 million ha in 1995. Native lumber is made into wood chips, with most exports going to Japan's voracious paper industry. Despite the supply of pinechips flowing through international markets, 60% of the chips exported from Chile in 1994 were from native species. The rapid expansion of forest plantations has resulted in serious negative social and environmental impacts, including the expulsion of hundreds of small farmers from their lands, serious soil erosion, decreased in-stream flows and lowered water tables, and a significant reduction in endangered native species and endemic wildlife populations (Wilcox, 1995).

With 80% of Chile's 15 million ha of native forest in private hands, much will depend on the actions of companies like Trillium, a US based corporation which plans to start logging this year and managing the 250 000 ha of forest it owns in the region. To their credit, instead of wholesale cutting and burning without replacing, Trillium's officials promise to adhere to the precept of sustainable forest management by emphasizing selective cutting of mature trees. Chilean environmentalists, reasonably skeptical about this plan, took Trillium to court, and in March 1997 they won a big victory when the Chilean Supreme Court invalidated the government's approval of the controversial Tierra del Fuego's logging project.

Opposition is building in Chile to the concentrated ownership of large parcels of native forest by a few companies. Therefore, Chilean environmentalists continue their work of challenging other logging projects such as a $1.3 billion pulp mill proposed by Celulosa Arauco S.A., a Chilean company partly owned by International Paper Co. of New York and a $100 million investment of a Washington State company to turn lenga rainforest near Rio Condor into furniture lumber and woodchips.

The skepticism of environmentalists is justifiable given the status of forestry legislation currently under discussion in Chile, which is necessary for the rational management of native forests, but that has some sections which threaten to exacerbate rather than alleviate the ailing health of Chilean forests. This legislation, 'Recovery of Native Forests and Promotion of Forest Management', would privatize many of the functions of Chile's National Forestry Corporation (CONAF), rather than strengthen its regulatory effectiveness. The law would stack a forestry consultative committee primarily with industry representatives and foresters to the exclusion of indigenous peoples, environmentalists, forestry workers, and scientists (Long, 1992). The law would officially authorize the continued substitution of native forest with plantations of the fast-growing Radiata pine and Eucalyptus.

4. The fate of rivers

Many rivers in Chile are now practically dead due to industrial and urban wastes and agricultural chemical runoff. One of the main sources of river pollution is Santiago that currently treats 3% of its sewage, allowing polluted water to flow directly across the central valley via three main river arteries and empty straight into the Pacific Ocean. The river Mapocho is virtually an open sewer that cuts through Santiago, accounting for the high rate of typhoid and hepatitis in the capital (Gomez-Lobo, 1992).

The government passed a law in 1989 that allows private companies to participate in building and operating sewage-treatment plants. In the country's most ambitious decontamination effort to date, authorities are planing a new 800 million dollar sewage-treatment venture for metropolitan Santiago. The city's water utility company, Empresa Metropolitana de Obras Sanitarias (EMOS), is inviting foreign and local investors to finance, build and run the plant, which will be the largest in the city. A multimillion operating plant is already in place in Valparaiso-Viña del Mar which treats the waters of the Marga-Marga which for decades flowed, untreated, directly into the ocean. In addition, paper mills dump wastes into rivers or the sea with little pre-treatment. Many of the new paper mill plants are supposedly now installing treatment facilities and cleaner production technologies.

No other river faces a more dramatic fate than the Biobio. This river flows from the Cordillera of the Andes, through magnificent gorges and forests of araucaria pine, all the way to the Pacific Ocean. Over one million people use the resources of the Biobio for drinking, irrigation water, recreation, and fisheries. ENDESA, the largest private company in Chile, is planning to construct six hydroelectric dams in the Biobio. The first of these, Pangue, is already 70% completed. ENDESA now says it will move ahead with the construction of the largest of the Biobio dams, called Ralco. Ralco would be a 155 m-high dam with 3,400 ha reservoir, which would displace more than 600 people, including 400 Pehuenche Indians. The upper Biobio, where the Ralco dam is planned, is home of the Pehuenche group of the Mapuche Indians, the last group of Mapuche who continue their traditional lifestyle. The dam would flood over 70 km of the river valley, inundating the richly diverse forest and its wildlife (J.P. Orrego, pers. com.). Environmental and indigenous rights groups oppose the project, not only because of the wide scale destruction it would cause, but also because projections of Chile's future energy requirements indicate that the energy it would produce will not be needed. In fact according to a recent study conducted by a research consortium, energy-efficiency measures could save the energy of all six dams proposed for the Biobio river. Its findings show that the nation could save an estimated 10 900 MW of energy and 1,670 MW of potential energy by the year 2010, or 19 700 and 3,200 MW by 2020 – the equivalent of six dams the size of Ralco or at least eight thermoelectric plants (University of Chile, 1997). Critics of Ralco also say that construction would violate the new Chilean Environmental and Indigenous People Laws and prior agreements between ENDESA and the World Bank. A similar fate awaits the Futalefu River where another major hydroelectric project is planned.

5. Ecological upset in fisheries

In the last decade, Chile has more than doubled its fish catch. Recent studies published by the Chilean Fisheries Development Institute (IFOP) indicate that local fish and shellfish stocks have undergone a notable decline due to the increase in 'fishing effort' over the last 15 years. Moreover, a US Agency for International Development study reports that a sustainable fish harvest for Chile would be half the current levels. Lack of regulations and over-fishing has provoked the collapse of entire species, like the anchovy, southern hake, Spanish sardine, and abalone populations. As over-fishing has dramatically diminished species like sardines and anchovies, jack mackerel is emerging as a probable food alternative for lower income populations – provided it remains abundant (Schurman, 1996).

Since the mid 1980s, Chile's jack mackerel catch has risen from 1.5 million tons in 1985 to 4.4 million tons in 1995, and slightly less in 1996. The increased catch has been used mainly to feed 1.5 million ton-a-year fishmeal industry, of which jack mackerel composes nearly two-thirds. As jack mackerel catches have surged, so too have production costs. The cost increase is reflected in the price of jack mackerel fishmeal, which rose from approximately $500 per ton in 1995 to $600-plus in 1996. This is the economy's way of saying the species are being fished to full sustainable capacity. Unless economic signals or governmental regulations put a break on jack mackerel extraction rates, the fish could suffer the same fate as anchovies (Gomez-Lobo, 1991).

Fish breeding, particularly of salmon, has become a giant international business in Chile. Although fish farms could be viewed as a food alternative, they provide much needed food while taking some of the pressure off dwindling fish populations in the wild. But in practice, aquaculture is often profoundly wasteful and destructive. Growing evidence suggests that large aquaculture has brought pollution and ecological imbalance to several inland lakes and streams. Salmon are raised in 15-m net cubes rafted together over several hectares of cold-water bays and fjords. Typically, 50 000–200 000 fish crowd each pen, until they reach 4 kg, the size at which they are harvested. They are fed a diet of fishmeal, and the trade off is dismal: 3 kg of fishmeal produces 1 kg of salmon. A large percentage of the meal falls to the sea floor along with feces, creating 'dead zones' where nothing lives. In late summer, it is common for algae blooms caused by the depleted oxygen and high bacteria counts to turn small lake bays into ecological deserts.

In addition, escape of caged salmon into the wild is causing serious environmental impacts. Salmon affected by the bacterial infection 'furunculosis' can easily spread the disease to wild fish. Interbreeding and hybridization between farm and wild salmon can cause genetic dilution or alteration of the gene pool leaving wild stock less competitive in its own habitat. Farm salmon can also outcompete and/or prey on other wild fish, significantly reducing their populations.

6. The ecological toll of modern agriculture

During the last twenty years, Chilean agriculture went through an unprecedented process of modernization characterized by: (a) the end of land reform; (b) reduced government control in the agricultural sector; (c) liberalization of international trade; and (d) financial liberalization and deregulation (Jarvis, 1985). Fast economic growth in agriculture was induced by a significant increase in the real exchange and by trade and financial liberalization. These policies increased the competitiveness of tradable crops, and by these means agricultural revitalization became an important source of economic growth. One expression of this phenomenon was the fast expansion in the production of exportable crops. Another expression was the adoption of high-input agricultural technologies and crop specialization (Gomez and Echeñique, 1988).

Among the major exportable crops in Chile are table grapes, apples, and other fruits. Most crops are grown by medium and large-sized commercial farms, including agribusiness type of operations. The area planted to commercial orchards rose from about 65 000 ha in 1965 to 190 000 ha in 1990. The fruit sector now produces 20% of agricultural output and employs 25% of agricultural labor. The sector generates about $625 million in exports (about 13% of total revenues). The growth of export agriculture prompted by free trade has occurred at the expense of domestic production; reductions in internal production of rice, wheat and maize range from 3.2–9.5% (Muchnik and Errazuriz, 1998).

This expansion was possible due to a set of political conditions that favored foreign investments, technological transfers, as well as massive imports and use of purchased agrochemical inputs. The role of the private sector in generating and transferring agricultural technology has been unprecedented (Jarvis, 1992). Although highly productive and profitable from the private sector's point of view, the ecological and social costs of this type of agriculture have not been fully assessed, and evidence shows that such costs are quite high.

Although in Chile, total production has nearly tripled since 1970, this growth in agricultural production has been accompanied by an increase in the imports and use of chemical inputs and tractors. In 1988, about 316 000 tons of chemical fertilizers (N–P–K) were used. In eight years, urea exhibited a 746% increase in use, mostly for application in cereals. Although between 1985–1990 wheat received 61.7% more fertilizer than in the previous decade, this resulted only in a 3.1% increase in wheat yields (Gomez and Echeñique, 1998). This is a clear indication of the inefficient use of applied fertilizers which has resulted in yields leveling off and in some cases even decreasing. In some cases soil degradation is so intense that its negative effect on production cannot be offset by enhanced fertilizer use (Harlin and Berardi, 1987).

In 1985, Chile spent about US $11.8 million for pesticide use and between 1985–1990 the use of pesticides increased to about US $16.5 million. In the last few years, use of insecticides has increased by 64% and that of herbicides by 220% (Gomez and Echeñique, 1998). As monocultures expand, impacts of modern agriculture on the resource base is highly concerning because of their potential for enhancing soil erosion and their heavy reliance on chemical fertilizers and pesticides. Widespread use of agrochemicals raises questions about human health, food safety, and environmental quality.

6.1. SOIL DEGRADATION

A LANDSAT study covering 34.5 million ha of the Chilean landscape estimated that about 78.5% of the surveyed area exhibit moderate to serious levels of erosion. Much of this area includes agroecosystems located in the rainfed coastal ranges, Andean slopes, and watersheds of the Central Valley. Cultivation of these steeper slopes significantly increases the potential for erosion. The study assumes that soil losses in many agricultural regions exceed the maximum level of 11.2 tons/ha that will permit a high level of crop productivity to be maintained economically and indefinitely (Elizalde, 1970). It is conceivable that erosion rates in Chile are similar to those in California's agricultural valleys. Therefore, it is possible that the soil loss tolerance level has been exceeded at least on 100–200 thousand ha. A soil eroding at a rate of 13 tons/ha/year will lose about 1 cm of soil in 10 years, enough to decrease cereal yields by 4% yearly in that period. A 25 tons/ha/year erosion rate in a thin soil (10 cm topsoil is quite common in hillside and marginal areas) can lead to a total loss of soil cover, and hence crop productivity in about 50 years (Larson et al., 1983).

Using a two-sector linear programming model, crop productivity and soil erosion were compared in organic versus conventional wheat systems (Altieri et al., 1994). According to the model, the organic management system which consisted of wheat undersown with a

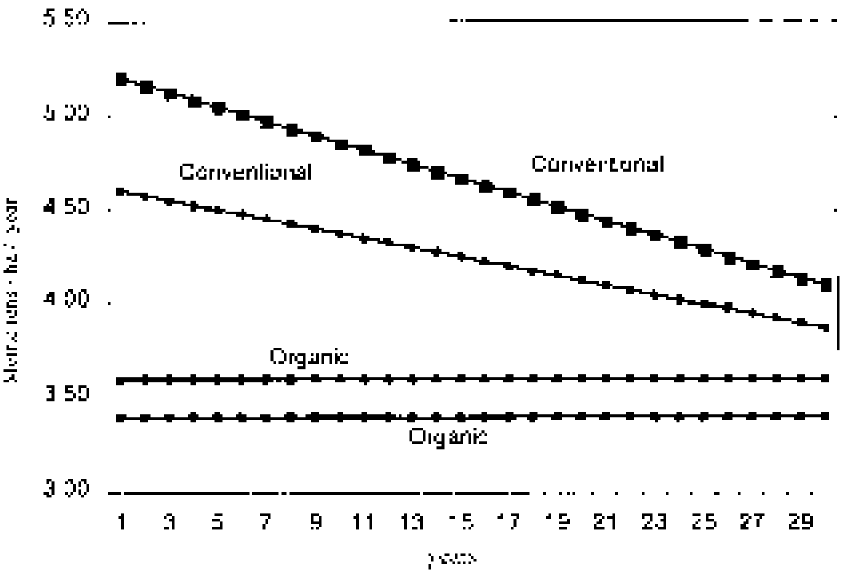

Figure 1. Projected wheat yields as a function of cumulative soil losses under conventional and organic farm mangement with irrigation in central Chile (after Faeth, 1993).

red clover living mulch fertilized with 15 metric tons of manure per hectare, showed lower estimated cumulative soil losses after 30 years, which kept yield relatively high over the long run (Figure 1). Conventional wheat monocultures exhibited higher rates of soil loss, which caused significant yield declines with time (Faeth, 1993).

As in many other Mediterranean regions of the world, expansion of irrigated agriculture in Chile into semiarid ecosystems has led to serious salinization problems. In the Valley of Copiapo, north of Chile, about 65% of the arable land under irrigation (7,931 ha) exhibits some degree of salinization. The high salt content of the water, high evapotranspiration rates and sprinkler irrigation are the main factors contributing to existing salinity problems. About 3,300 ha of vineyards under sprinkler irrigation are affected which has already led to 40% reduction in productive potential (Rodas and Chanduvi, 1989).

6.2. PESTICIDE POLLUTION

In 1988, about seven million kilograms of pesticides were used in Chilean agriculture and their use has increased since then, reaching about eight thousand tons. The stringent cosmetic standards and quarantine requirements imposed by industrialized countries importing Chilean fruits, often encourage use of pesticides by fruit growers. The presence of just one specimen of a quarantined insect pest results in automatic rejection of a shipment of exported fruit. From 1983–1989, more than 1.4 million tons of Chilean fruits were rejected in international ports due to the detection of at least one individual of *Quadraspidiotus perniciosus*. In order to avoid such risk and associated economic losses, Chilean fruit growers intensively spray their crops to totally eliminate pests. In this way, international standards create pervasive incentives for farmers to pursue chemical pest control.

TABLE I. Pesticide expenditures in Chile and pesticide use in three periods (after Burton and Philogene, 1986)

Millions of 1990 US dollars				
	1980	1982	1985	1990
Insecticides	5.1	6.1	6.5	8.2
Herbicides	1.9	1.6	2.4	3.1
Fungicides and others	3.2	3.8	4.1	5.2
Totals	10.2	11.5	13.1	16.5
100 kg of active ingredients				
	1976	1978	1988	
Total insecticides	1,904	4,242	5,036	
Total fungicides	30,858	57,549	59,552	
Total herbicides	1,191	3,550	4,503	

Studies on the impact of pesticide use on the Chilean environment are virtually non-existent and only now begin to emerge. Current regulations in Chile prohibit the importation, production and application of DDT, Aldrin, Dieldrin, Chlordane and Heptachlor, however, before 1980, about 45 400 kg of DDT active ingredient were used (Table I). Considering that persistence in the environment of most organochlorides ranges between 5–20 years, DDT and Aldrin can still be detected in many Chilean soils. Despite such regulations, large-scale use of pesticides such as Parathion, Paraquat, Lindane and pentachlorophenol all severely restricted or even banned in Europe, Japan and the United States continues in Chile (Rozas, 1995).

The environmental and social costs of pesticide use have not been assessed in Chile, but as a reference point it is worth mentioning that a country such as the US where about 500 000 tons of 600 different types pesticides are used annually, at a cost of $4.1% billion, the total environmental and social costs from such applications run in the range of $8 billion dollars per year (Pimentel et al., 1993). As a rule of thumb it could be argued then, that in Chile environmental and social costs are roughly double than the cost of pesticide purchase and application (approximately 30 million dollars per year).

Although the agroexport sector continuously monitors for the presence of pesticide residues in fruits and vegetables, mainly to comply with the United States Food and Drug Administration's pesticide enforcement sampling of produce imported from Chile, such monitoring does not account for the environmental fate of agrochemicals beyond the surface of fruits. There is evidence that often less than 0.1% of the pesticides applied to crops actually reach target pests. Over 99% of the chemicals move into ecosystems to contaminate the land, water and air. Given the non-stringent nature of pesticide applications in Chile, it should be a matter of concern the fact that these unmeasured pesticide levels in soil and water in Chile may pose threats similar to those experienced in other agricultural regions of the world (Gonzalez et al., 1990).

Such monitoring does not account either for effects of pesticides on human health despite the fact that there exists growing evidence of the serious impact of pesticides on temporary workers in the export fruit sector, mainly women who are poorly paid. Public health effects of pesticides are, according to official figures very low. However, an independent study conducted in 1989 by the Comision Nacional Campesina in which the health of 155 random farm workers was monitored, reported that 83% of the farm workers applied products such as Parathion, Azinphos, Captan and Paraquat without protection. About half of the farm workers complained of frequent headaches and 60% exhibited nausea and abdominal pain. Some of the reported effects on women include chronic and irreversible damage to their health, such as genetic deformations, miscarriages, infertility, damage to the nervous system, loss of eyesight, skin diseases, etc. (Sepulveda et al., 1990).

A recent report by the United Peasant and Ethnic People's Movement (Mucech) states that during the 1997 harvest season, more than 100 women harvesting fruit and vegetable crops in Central Chile came down with poisoning from highly toxic pesticides. Workers have complained to Mucech that, on occasions, they have been forced to work while aircraft sprayed pesticides on the fields, disregarding obligatory waiting periods. Besides being exposed to health risks, farm workers are temporary, work without contracts, without any ancillary benefits or medical insurance and without any source of labor organization; and they have no means of support in the event they are poisoned.

6.3. MONOCULTURE AND PEST OUTBREAKS

It has been widely documented that the expansion of monoculture exacerbates pest problems, as larger homogeneous agricultural areas support more pest species. In Chile, this phenomena is illustrated by the pest situation in apple orchards which have expanded in area from 13 800 ha in 1965 to about 25 860 ha in 1989. This area expansion has been followed by an increase in the number of pest species attacking apples from 7 to 19 species (Table II). Many of these new pests are introduced, some became secondary pests due to insecticide disruption and others (several native species) probably shifted from native plants to apples as the natural vegetation was replaced.

A documented negative effect of the heavy reliance of monocultures on insecticides in Chile is the disruption of natural biological control in agricultural systems due to the elimination of the beneficial fauna. In Chile, there are at least eight known cases of insect and mite species that reached pest status due to the elimination of natural enemies with pesticides, including the grape mealybug, citrus whitefly, and several mite species in avocado, grapes, strawberries, walnut and peaches (Table III, Ripa and Caltagirone, 1990).

7. Alternatives to high-input agriculture

7.1. BIOLOGICAL PEST CONTROL

Most agricultural research centers and universities in Chile have traditionally promoted high-input agricultural practices. An exception were INIA's efforts before the 1990s on biological pest control that placed Chile in a pioneering role within Latin America. Between

TABLE II. Primary and secondary insect pests and mites attacking apple orchards in Chile reported during two historical periods (after Gonzalez, 1975 and Gonzalez, 1989)

Species	1975	1989	Origin
Aculus schlechtendali		x	exotic
Aphis citricola		x	exotic
Bryobia rubrioculus	x	x	exotic
Callisphyris vespa		x	native
Chilecomadia valdiviana		x	native
Cydia molesta		x	exotic
Cydia pomonella	x	x	exotic
Edwardsiana australis		x	exotic
Epidiaspis leperii		x	exotic
Eriosoma lanigerum	x	x	exotic
Hemiberlesia rapax		x	exotic
Lepidosaphes ulmi		x	exotic
Orgyia antigua	x	x	exotic
Panonychus ulmi	x	x	exotic
Pantomorus cervinus		x	exotic
Proeulia chrysopteris		x	native
Quadraspidiotus perniciosus	x	x	exotic
Scolytus rugulosus		x	exotic
Tetranychus urticae	x	x	exotic
Total number of pest species	7	19	
Area under apple cultivation (thousand ha)	12	25.8	

TABLE III. Insect and mite species that have reached pesticide induced pest status in various crops due to elimination of natural enemies (after Ripa and Caltagirone, 1990)

Pest species	Crops affected	Insecticides causing perturbance	Natural enemies affected
Pseudococcus affinis (mealybug)	Grapes	Pesticides used to control thrips during flowering	At least 6 species, but mainly *Pseudaphycus flavidulus*
Aleurothrixus floccosus (whitefly)	Citrus	OP to control scales and mealybugs	The parasitods *Amitus spiniferus* and *Cales noacki*
Panonychus citri (red mite)	Citrus	Insecticides to control white scale and thrips	*Stethorus* sp. and *Oligata pigmaea*
Oligonychus yothersi (red mite)	Avocado	Insecticides to control white scale, mealybugs and thrips	Phytoseiids
Tetranychus urticae (mite)	Raspberry	Insecticides to control thrips and snout beetle	Phytoseiids, *Stethorus* sp. and *Oligata pigmaea*
Oligonychus vitis (mite)	Grapes	Insecticides to control thrips during flowering, snout beetle, scale and mealybug.	Phytoseiids, *Stethorus* sp. and *Oligata pigmaea*
Tetranychus urticae, *Panonychus ulmi* (mites)	Walnuts, peaches, prunes	Insecticides to control codling moth, oriental fruit fly and San Jose scale	Phytoseiids

1903–1984, approximately 66 species of beneficial insects were introduced against several pest species of crops such as citrus, grapes, peach, apple and potato. Forty-two of these species became adapted and established. Sixty percent of the targeted pests are under complete or substantial control, 38% of the introduced predators and 24% of the parasitoids are responsible for maintaining this successful degree of control. It is estimated that biological control of several pests, i.e., *Aonidiella* sp. and the purple scale *Lepidosaphes beckii* (Homoptera: Diaspididae), and several species of the family Aphididae has saved the Chilean citrus industry approximately US $900 000 per year (1983 dollars) in pesticide control (Gonzalez and Rojas, 1966; Zuñiga 1985).

A recent success is the biological control of the aphid species (*Sitobium avenae* and *Metlopolophium dirhodum*) detected in 1972 in cereal fields in Chile. Despite the presence of resident natural enemies, these aphids reached outbreak proportions, which led to aerial application of insecticides over 120 000 ha of wheat. In 1975, the aphids and the BYDV virus they transmit caused a loss of about 20% of wheat production (Zuñiga, 1985). In 1976, the Chilean government's INIA initiated an integrated pest management program, which included the introduction of several aphidophagous insects and parasitoids against *M. dirhodum* and *S. aenae*. Five species of predators were introduced from South Africa, Canada and Israel and 9 species of parasitoids of the families Aphidiidae and Aphelinidae were brought from Europe, California, Israel and Iran (Zuñiga, 1985). In 1975, more than 300,000 Coccinellidae were mass reared and released, and from 1976–1981, more than 4 million parasitoids were distributed throughout the cereal areas of the country. Today, aphid populations are maintained below the economic threshold level by the action of these biological control agents (Zuñiga, 1985).

7.2. CONVERSION OF LARGE-SCALE CROPPING SYSTEMS TO ORGANIC FARMING

7.2.1. Vineyards

In order to maintain the status of Chilean fruits as an identifiable and preferred product in the international markets, some Chilean farmers are now starting to produce high quality grapes with environmentally benign technologies, capitalizing on the green markets of northern countries. Agricultural practices are a substantial departure from conventional farming and include management techniques such as cover cropping, mulching, composting, release of beneficial insects, etc., all aimed at maintaining profitability while conserving soil, water, energy, and biological resources. From 1994–1997 a study was conducted in the Aconcagua Valley, a key table grape-growing region of Central Chile to establish the agroecological basis for the conversion of conventional vineyards to sustainable management (Altieri et al., 1994). For the purpose of the conversion study, a range of vineyards representing different levels of management intensity were selected in the Aconcagua Valley. Seven participating farmers were asked to leave aside a one hectare block of their vineyards in order to design and test alternative low-input technologies in such blocks (OPS). The remainder of the area was managed as usual with high-input conventional methods, from which one hectare block (CPS) was selected, usually adjacent to the OPS block. In this way, farmers were able to compare the performance of the two adjacent blocks under high- and low-input management in their own fields and under their own conditions.

The organic plots (OPS) did not receive applications of synthetic chemical pesticides or fertilizers, using instead cover crops, manure, biological control, etc. Cover crops consisted of a mixture of barley (*Hordeum vulgare*) and vetch (*Vicia atropurpurea*) planted at a rate of 150 and 50 kg/ha respectively. Manure was applied at rates of 12 tons/ha.

In each block several biological and agronomic parameters (i.e. soil fertility, soil mesofauna, insect pest and associated natural enemies, weed abundance, grape yields, cover crops biomass production, costs of production) were monitored throughout the corresponding growing season.

After three seasons of monitoring, it was found that OPS blocks exhibited tolerable population levels of the grape mealybug (Figure 2), no significant epidemic outbreaks of pathogens, high degree of weed suppression and acceptable yields when compared with CPS blocks. Results from the study support the hypothesis that cover crops act as ecological turntables, which have cascading effects on soil–microbial and plant–arthropod interactions. Biomass from cover crops also harbored a number of beneficial insects and exerted suppressive effects on competitive weeds.

Although initial production costs in OPS blocks were similar to those in CPS blocks, as conversion progressed and processes of nutrient cycling and pest regulation became increasingly more self-sustaining, input substitution needs decreased lowering expenses on items such as composting, thus bringing total production costs to levels 20–30% lower than in CPS blocks (Table IV).

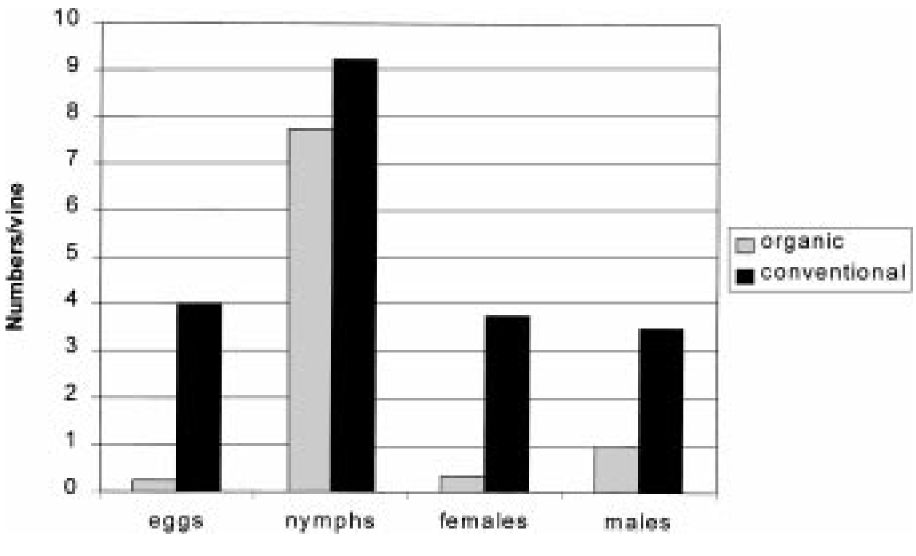

Figure 2. Seasonal abundance levels (mean of 12 samples over a 3 month period) of various life stages of the grape mealybug in conventional and organic vineyards in central Chile. The results are significant given that the three stages that reached higher levels in CPS blocks are the ones that represent the higher damage potential. Egg masses represent future generations, females, the reproductive potential and nymphs, the potential damage, given that they are the ones that ascend the vines and colonize grape clusters.

TABLE IV. Table grape yields, soil organic matter content and total cost of production in three conventional (CPS) and organic (OPS) production systems in Central Chile after 3 years of conversion

Vineyards	Grape yields (tons/ha)	% SOM	Total direct costs ($US)[a]
1			
OPS	28.7	3.36	2,890
CPS	27.2	3.01	2,923
2			
OPS	16.2	3.57	2,570
CPS	15.9	3.23	2,650
3			
OPS	14.3	4.7	2,430
CPS	13.5	4.1	2,772

[a] Labor cost were somewhat higher in OPS blocks, although cost associated with mechanical operations (plowing, harrowing, spraying trips, fertilization, etc) were lower in OPS. During the third year of conversion, production costs in OPS blocks decreased about 12% compared to CPS blocks due to the substantial reduction in average compost application (from 12.5 to 2.5 tons/ha).

Results from the vineyard studies may be considered conservative in demonstrating the agronomic, environmental and economic superiority of organic production, since they were short term studies that did not capture the potential for increased yields in organic systems that typically result after the transition from conventional production has been completed (Faeth, l993). The process of converting those conventional high-input, crop production systems, to organically managed systems, is not merely a process of withdrawing external inputs, with no compensatory replacement or alternative management. Chilean researchers have realized that considerable ecological knowledge is required to direct the array of natural flows to sustain yield in organic systems.

7.2.2. Other crops

Recent research initiated by agronomists near Chillan in the VIII Region of Chile, is documenting the agronomic as well as ecological changes that occur during the transition as a series of vegetable crops are converted from high-input to low-input managed systems. The evaluation criteria for the different management strategies includes environmental parameters as well as economic and yield comparisons. Results from the 1996/1997 season are encouraging showing that in only one year, yield increases in most crops under organic management were higher than in conventional systems (Cespedes, pers. comm.).

As in other countries, it may be desirable that in Chile farmers begin to adopt alternative practices with the goal of reducing input costs, preserving the resource base and protecting human health and wildlife. Peasant farmers are more close to a sustainable agriculture than large-scale farmers because, due to their poverty conditions, most of them do not rely as much on chemical inputs, but, on the contrary, take advantage of naturally occurring interactions for pest control and soil fertility. Chilean peasant farmers emphasize practices such as rotation, intercropping, cover crops, green manure, etc. – all practices that enhance biological interactions that benefit productivity (Altieri, 1994).

In every agricultural region, there are certain crops that are more dependent on chemical inputs than others for optimal production. For example, in an agricultural valley in Colina, near Santiago, crops such as wheat, carrots, potatoes, and peas are grown with minimal insecticide applications and are therefore more amenable for implementation of alternative practices for pest control. Conversely, crops such as broccoli and cauliflower are highly dependent on insecticides and therefore the transition of these cole crops to low-input pest control might prove more difficult or take longer time than less insecticide dependent crops. On the other hand, development of pest control alternatives in these crops may offer substantial environmental benefits derived from withdrawal of pesticide use and associated pollution problems.

In Quillota, north of Santiago, a region which enjoys a special semi-tropical climate, fruit trees such as avocado, chirimoya, kiwi, and loquat are grown virtually free of insecticides. Apart from sporadic attacks of mealybugs and mites, chirimoyas and avocados are considered pest free crops. These species, therefore, have a high potential for organic management and represent prime candidates for implementing sustainable, low-input management practices.

Clearly, more research efforts are needed in Chile on developing sustainable agricultural management technologies which enhance production and preserve the natural resource base on which agricultural production depends. Yield and environmental data (i.e., erosion rates, enhanced biological control, etc.) from such studies is vital for evaluating the economic viability of alternative systems and to account for natural resource costs and benefits of the various technologies.

8. Conclusions

Although it is important to recognize that economic liberalization policies have been effective in reallocating agricultural resources toward more competitive activities, the process involved high social and ecological costs. As shown in this article, grave questions surface about the ecological sustainability of the neoliberal model, as over 87% of Chile's exports are based on only four natural resource sectors, presently exploited without adequate environmental safeguards (CEPAL, 1991). In particular, the ecological footprints of modern agriculture are quite worrisome. Encouraging an increase in Chilean natural resource exports through NAFTA or Mercosur will expand environmental disruption threatening the resource base and prospects for long term productivity in the forestry, fisheries and agricultural sectors. The situation is aggravated by the fact that Chile has few environmental laws to enforce. Various decrees and regulations are applied through 9 different ministries and 28 governmental services, but no authority exists to coordinate environmental matters. A legislative environmental package has been slowly moving through the Chilean Congress for some years, with private national and foreign industry lobby blocking it at every turn.

In addition to marginalizing poor farmers and indigenous people, the neoliberal model has plundered the rich forestry, agricultural and fishery resources. Sell-off of public lands is concentrating natural resources in the hands of the wealthy and foreign interests, which then encourage over-exploitation of environmental resources (Wilcox, 1995). Government handed-out subsidies to forestry conglomerates have displaced small-scale operations and encourage monoculture of pine and eucalyptus exotics at the expense of native forest. Small fishermen have also seen their livelihoods threatened as foreign owned companies concentrate half of the fish catch and fishmeal production. Policies favoring concentration of land ownership have, combined with export crop subsidies, nearly wiped out the campesino farming economy, while agrochemical use increases degrading the resource base and threatening public health (Larraín, 1996). The undiscriminating liberalization policies meant that small farmers, especially those growing annual crops, bore heavy losses as a consequence of lower costs for their produce and difficulties in competing with imported foods at depressed prices (Muñoz and Ortega, 1991).

Clearly, when considering the above trends, the Chilean economy is moving along an unsustainable path. Since economic growth in Chile does not account for depletion of the natural (and social) capital on which the future of the economy depends, the generalized perception by Chileans of increased economic health is a partial delusion. Yet it is this delusion that guides Chile's economic course toward further environmental degradation. The model proponents forget that ecosystems sustain economies; economies do not sustain ecosystems. The challenge for Chile in the new decade is to find ways to sustain economic growth, promote more regional integration, and protect the environment while moving toward a more equitable model of development. Agriculture and trade will play a major role in such process.

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