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Author
Galt, Ryan E

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Abstract

Almost 30 years after its introduction, the "circle of poison" remains a common conceptualization of the global pesticide complex among scholars and especially in popular understanding. The circle of poison describes a situation in which pesticides banned in industrialized countries continue to be manufactured there and exported to developing countries, are then used in developing countries almost entirely on export crops, and return to industrialized countries as pesticide residues on food. Using secondary data and a case study of pesticide use in Costa Rica, I review the applicability of the circle of poison conceptualization to the current global pesticide complex. I argue that (1) the circle of poison is no longer accurate due to important global changes in pesticide regulation, production, trade, sales, and use driven by a number of dynamic economic, social, and ecological processes; (2) using industrialized countries' pesticide regulations as proxies for safety should be replaced by multi-characteristic risk assessments; and (3) Wright's (1986) circle of poison revision should be updated because of export farmers' adoption of newer classes of pesticides. The paper concludes by offering a new characterization of the global pesticide complex vis-à-vis pesticide use in developing countries: pesticide divergence by market orientation.

Keywords: pesticides; circle of poison; global pesticide complex; developing countries; industrialized countries; Costa Rica

1. Introduction

In the 20th century, pesticides became an integral and problematic part of agriculture in many parts of the world. Inorganic pesticides—those based on elements like copper, sulfur, lead, etc.—gave way in the 1940s to synthetic pesticides derived from organic chemistry, especially the organochlorines and organophosphates. Since then, numerous other kinds of pesticides have been developed and released into agricultural fields and the environment around the world.

Many of the problems created by pesticides, including substantial threats to human health, wildlife, and terrestrial and aquatic ecosystems, have received substantial attention but remain significant, as highlighted in recent ecosystem assessments (Falkenmark et al., 2007, MEA, 2005). Monocultural production of biofuels, the effects of global warming on pest ecology, and increased manufacturing in industrializing countries suggest possible increased use, while regulations and the "mainstreaming" of the idea of sustainable agriculture suggest the possibility for decreased use. Within the context of the problems caused by pesticides and uncertainty in the forces shaping future pesticide use, this paper examines the current global pesticide complex.

The global pesticide complex, defined as encompassing all aspects of pesticides' lifecycles from conception to environmental fate, is extraordinarily complicated. This complexity arises from overlapping spatial patterns for each of the 600-plus pesticide active ingredients (ai's) in the world, i.e., where specific pesticides are developed and manufactured, where they are traded and sold, where they are used, where they move, and where they settle and degrade or persist. All of these geographically rooted economic and ecological processes occur within international, national, and subnational pesticide and food regulation frameworks that have varying characteristics and strengths, sometimes exerted both within their territorial homes and beyond them as an increasingly globalized food system (Goodman and Watts, 1997, McMichael, 1994). The global pesticide complex sets the preconditions for pesticide use and fate in specific areas, in that it influences which pesticides (1) farmers can use, (2) farmworkers are exposed to, (3) citizens consume as residues on food, and (4) move about and settle in the environment. Data on pesticide regulation, production, trade, sales, use, and fate remain scant and, when they do exist, are geographically uneven in nature. This makes characterizing the global pesticide complex difficult.

Despite or perhaps because of this lack of data, a characterization of the global pesticide complex from the early 1980s—the circle of poison—remains very important today, and, despite revisions, continues to dominate thinking about the global pesticide complex in some circles. Weir and Schapiro (1981) first explicitly conceptualized the global pesticide complex as the "circle of poison." The circle of poison describes a situation in which pesticides banned in industrialized countries continue to be manufactured there and exported to developing countries, are then used in developing countries almost entirely on export crops, and return to industrialized countries as pesticide residues on food. The circle of poison persists as a prominent characterization in popular imagination and, to a lesser extent, in academic writing, where scholars use it to describe both the global pesticide complex and pesticide use in developing countries.

Using secondary data and a Costa Rican case study, this paper examines the global pesticide complex, and evaluates whether the circle of poison remains an apt description of it. It explores (1) international agreements and regulations concerning pesticides, (2) global shifts in pesticide manufacturing, (3) pesticide exports from industrialized countries, and (4) sales and use in developing countries.

I make three related arguments about the global pesticide complex. First, I argue that the circle of poison conceptualization is largely not applicable to the current global pesticide complex. Many drivers of change in the last three decades—including pest resistance to older pesticides, the imperatives of capital accumulation manifested in the form of newer pesticide products, and significant pressure from environmental and consumer groups spurred by media attention to the circle of poison—have helped to render the circle of poison a much less relevant description of the global pesticide complex. Second, by examining the international regulatory status of pesticides used in Costa Rica, I argue for a replacement of a common practice based on circle of poison thinking—using pesticide regulations from industrialized countries as proxies for safety—by adopting multi-characteristic risk assessments that can be equally applied to industrialized and developing countries. Third, based on the Costa Rican case I argue that Wright's (1986) revision of the circle of poison concerning the types of pesticides used in export crop production should be rethought in light of export farmers' adoption of newer classes of pesticides.

The paper proceeds as follows. I first introduce the circle of poison. I then examine recent international regulatory frameworks, the shifting geography of pesticide manufacturing, and pesticide exports from industrialized countries. I then turn to pesticide sales and use in developing countries, focusing on recent data from Costa Rican export vegetable production. The conclusion proposes a new conceptualization of the global pesticide complex vis-à-vis pesticide use and market segmentation in developing countries and identifies opportunities for future research.

2. The *Circle of Poison*

Weir and Schapiro's *Circle of Poison* (1981) popularized concerns about pesticide use around the globe, but especially in developing countries. One of the main figures of the book is that "[a]t least 25 percent of U.S. pesticide exports are products that are banned, heavily restricted, or have never been registered for use here" (Weir and Schapiro, 1981, p. 4). This figure comes from a General Accounting Office (GAO)[1] report from 1979 that cites a 1976 Bureau of the Census report showing that over 161 million pounds of the 552 million pounds exported (29 percent) were not registered for use in the US (GAO, 1979, p. 50).

Weir and Schapiro's seminal argument sparked a second surge of interest and concern about pesticides in the industrialized world. By combining concerns for the environment and human health with an understanding of global political economy,[2] the book shaped this second surge of interest into an extended geography of concern about pesticides. Carson's *Silent Spring* (1994 [1962]) created the first surge of interest in focusing attention on synthetic pesticide use in industrialized countries and this greater public scrutiny had driven considerable changes within nation states, including the formation of the Environmental Protection Agency (EPA) in the US and many bans on the organochlorines that manufacturers continued to ship to developing countries because of lack of changes to export regulation. *Circle of Poison* responded to these new conditions and challenged citizens to confront the transnational chemical companies that engaged in dumping and the states that abetted it. The *Circle of Poison* "became virtually a household phrase among environmentalists, political activists, and people concerned with food quality and consumer safety" (Wright, 1986, p. 29). Previous work of the authors caused a major reaction:

> The United Nations passed a resolution on hazardous exports; new, tough legislation was introduced in Congress by Rep. Michael Barnes; the press heavily reported the stories; several third world governments issued new regulatory standards for pesticides; and activists here and abroad opened new initiatives to bring pressure on government agencies and the corporations responsible (Weir and Schapiro, 1981, p. xi).

The *Circle of Poison* reinforced this progress and helped spur the formation of the Pesticide Action Network (PAN) in 1984 (Schaeffer, 1999), articles in popular magazines (Wolterding, 1981), documentary films (Richter, 1981), books in other countries (CESAP, 1985), investigations by GAO (1989, 1986), and U.S. congressional hearings (1991).

The circle of poison also cemented in place a framework for thinking about pesticide use in the global economy that remains part of lay, and sometimes academic, understandings of the global pesticide regime. The idea has strong roots in world systems theory (Wallerstein, 1974), with its conceptualization of a global division of labor that is determined by a country's position in the industrialized core or the underdeveloped periphery. Using the language of world systems theory, the core produces the pesticides, regulates them internally, but exports to the periphery the ones that have been banned. These pesticides are used in the periphery, which, because of colonialism's lasting legacy, is oriented to producing export crops sold to the core. Despite regulation in the core, pesticide manufacturing workers and consumers in the core are still exposed to pesticides banned there.

The circle of poison still has currency in some circles of academia. Recent work in sociology (Adeola, 2001), political ecology (Vandermeer and Perfecto, 1995), agricultural economics (Pingali and Gerpacio, 1998), and global environmental change (Guivant, 2001) cite the argument.[3] Beck's highly influential *Risk Society* (1992, p. 44) contains the circle of poison conceptualization, which he calls “the boomerang effect.” Roberts and Thanos (2003, p. 70) in their introductory text on environmental problems in Latin America state that the region “has historically served as both a testing ground and a dumping ground for pesticides banned or restricted in the United States.” In a very recent book on organic agriculture, Duram (2005, p. 23) similarly cites the circle of poison idea — “[c]hemical corporations simply sell these chemicals to developing countries that have lower environmental regulatory standards” — to explain the existence of banned pesticides on produce imported to the US.[4] Although many of these studies appear after 2000, none of these works rely on new empirical data on the global pesticide complex. They assume little to no change since the conceptualization’s introduction.

In addition to being prevalent in some recent scholarship, I have found that the circle of poison dominates lay ideas on the global pesticide complex. During my interactions with students and non-academics in the US in which I explain my research on pesticide use in Costa Rica for the national and export markets, the circle of poison question almost always appears. Similarly, in my discussions with Costa Rican farmers, many expressed their very valid concern that the US and Europe exported banned pesticides to Costa Rica, but they did not know which ones.

Because the circle of poison remains an important framework for understanding the global pesticide complex, I find it important to examine the current applicability of the framework while remaining true to the political ecology approach implicit in Weir and Schapiro’s work. With the exception of Wright’s work (Wright, 1986, 1990, 1991), scholarship that examines various aspects of the global pesticide complex since the early 1980s has focused on the political and regulatory side (Hough, 2003, 1998, Tait and

Bruce, 2001). While important, these analyses lack empirical data to examine material questions such as where different specific pesticides are manufactured, traded, used, and remain as residues. These analysis, and those that suppose that the circle of poison conceptualization remains applicable, also neglect political economy in the sense that the process of capital accumulation is extraordinarily dynamic and leads to a constantly changing geography of uneven development (Smith, 1984). Thus, with a materialist political ecology framing that is attentive to political economy as the intersection of regulation and capital accumulation, I ask: do recent developments necessitate a new conceptualization of the global pesticide complex regarding manufacture, trade, use, and residues? To answer this question, the analysis below traces changes in the last three decades, from 1976 to 2008.

3. Evaluating the Circle of Poison vis-à-vis Global Pesticide Regulation, Production, and Trade

The negotiation of two important international agreements on pesticides have likely helped to decrease the export of banned and severely restricted pesticides from industrialized to developing countries. Indeed, Hough's (1998) examination of the seven areas of pesticide politics—including human poisoning, environmental pollution, pesticide residues on food, and international pesticide trade—reveals that pesticide trade comprises one of only two with an adequately developed global "regime" to address it. The implementation of Prior Informed Consent (PIC)[5] stands as an important step in creating this regime.

3.1. Prior Informed Consent: The Rotterdam Convention

Global negotiations created PIC as an agreement that allows countries to communicate their findings about dangerous pesticides to one another in the context of international trade. If two or more countries in a PIC region ban or severely restrict a pesticide, a committee reviews the evidence to decide if the chemical meets the criteria established by the PIC convention and should be on the PIC list. If the committee decides affirmatively, the committee creates a decision guidance document that goes to each country's designated national authority. This designated national authority then decides if it will allow continued importation of the chemical (UNEP and FAO, 2004).

Negotiations concerning PIC began in the mid-1980s, but it entered into force in 2004. Under pressure from environmental groups, the United Nations Food and Agriculture Organization (FAO) accepted PIC as a voluntary procedure in 1987, including it in the *International Code of Conduct on the Distribution and Use of Pesticides* (FAO, 1990). Activist group PAN was heavily involved, "challenging and working with FAO member countries to include in its provisions concepts of social and environmental responsibility" (Moore, 1993, p. xii). The chemical industry also played a role—The International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP) required member firms to comply with the code—as it did not see compliance as incompatible with profits largely derived from sales of newer, and thus patented, pesticides. The first round of PIC notifications were sent by exporting manufacturers in September of 1991 (Dinham, 1993). Despite numerous criticisms of PIC, Dinham (1993, p. 5) points out that "it is an important precedent, not only allowing governments to reject hazardous imports, but also as a means of transferring information and providing a structure for the work of advocacy groups in the Third World."

The Rotterdam Convention, aimed at making PIC a legally binding treaty, was held in 1998. The treaty entered into force with legally binding obligations on February

24, 2004, after the fiftieth country, Armenia, ratified it on November 26, 2003 (UNEP and FAO, 2004). There were initially 73 signatories, but the current website notes that there are 120 parties, although it lists 139 (UNEP and FAO, 2008). Some say inclusion of a pesticide on the PIC list is a "worldwide ban," but this is hardly the case (Smith, 2001). Non-parties to the treaty are not bound by it and can thus freely trade pesticides on the PIC list. Additionally, member countries can decide for if they want to continue to import pesticides on the PIC list. The notification alone is mandatory.

The PIC list of pesticides, starting with 17 active ingredients, now contains 24 for which importing countries must be notified regardless of their formulation (Table 1). Many of these were the focus of *Silent Spring*—older organochlorine pesticides that persist in the environment and accumulate in fatty tissue, and known to or suspected of causing cancer and/or disrupting the endocrine system (Colborn et al., 1997). This group and the group of pesticides with certain formulations (Table 1) also consists of very acutely toxic organophosphate insecticides that have caused large numbers of worker and farmer poisonings and deaths, especially in developing countries (Dinham, 1993, Roberts et al., 2003, Wright, 1986, 1990). Some industrial chemicals and some asbestos minerals are included on the PIC list. The current list will likely be amended to include more substances in the future, as has happened from 2004 to 2008. Five additional pesticide active ingredients, including organophosphates and carbamates and the problematic herbicide alachlor, are being considered for inclusion on the list of pesticides in any formulation (UNEP and FAO, 2008).

Dinham (1993) has rightly pointed out that PIC is limited in its future achievements because it is trade-based mechanism. Some hazardous pesticides are only used in tropical regions, so they have never been banned in temperate countries and will not be controlled under PIC. Other pesticides may be much less dangerous under conditions in industrialized countries and will not be banned there, but may present an extreme hazard when used under conditions in developing countries (Thrupp, 1990). But despite its shortcomings and very slow evolution, PIC has likely helped to inform many officials in developing nations about the hazards of pesticides banned and severely restricted in industrialized countries, something that did not occur before *Circle of Poison*.

3.2. Persistent Organic Pollutants: The Stockholm Convention

The Stockholm Convention is another major step in addressing international trade of many of the pesticides featured in *Circle of Poison*. In 1995, the United Nations Environment Programme identified twelve persistent organic pollutants (POPs) as targets of a global phase-out effort (Johansen, 2003, UNEP, 2004). This led to the Stockholm Convention, which aims to eliminate these 12 chlorine-based chemicals[6] that are known to persist in the environment, have been widely distributed geographically, accumulate in living organisms' fatty tissues, and cause harm to humans and the environment (Johansen, 2003). The Stockholm Convention recently entered into force on May 17, 2004 (Secretariat for the Stockholm Convention on Persistent Organic Pollutants, 2004). As an international law, it obliges governments to reduce or eliminate the use of POPs, many of which were featured in *Silent Spring* and *Circle of Poison*. In the four years since its inception, no chemicals have been added (UNEP, 2008).

The current POPs list featured in Table 2 includes industrial chemicals such as PCBs, the extremely toxic industrial byproducts dioxin and furans, and many organochlorine pesticides, specifically aldrin, chlordane, DDT, endrin, heptachlor, hexachlorobenzene, mirex, and toxaphene. Considerable overlap exists between the POPs and PIC list: seven of nine POP pesticides are also on the PIC list.

The reforms in global economic and environmental governance embodied in the PIC and POPs agreements speaks to the successes of environmental and consumer groups in pressuring states and international bodies to address the question of international trade in pesticides. These changes should prompt a reconsideration of the circle of poison's continued applicability. We now turn to another facet of the global pesticide complex: the changing geography of pesticide production.

3.3. Geographical Shifts in Pesticide Production

Pesticides remain big business. Weir (1987, p. 21) reports that in 1983, pesticide sales totaled about $13 billion worldwide, the result of an annual growth rate of 12.5 percent since the late 1960s. By the mid-1990s, the more than 5 billion pounds of pesticides applied annually worldwide cost purchasers $21 billion (Pimentel and Greiner, 1997, p. 51). CropLife International's (2005) figures show that industry sales increased by 2.5 percent (adjusted for inflation) from 2004 to $31.19 billion in 2005.

Important geographic shifts in pesticide production have occurred in recent decades, an unsurprising situation considering the major economic changes that have occurred with economic globalization (Dicken, 2003). For one, very few if any of the organochlorines prominently featured in *Circle of Poison* are still manufactured in the United States or Europe. None of the "Dirty Dozen" on the POPs list are produced in, exported from, or imported into the US (EPA, 2002). CropLife International stated in 2001 that none of its research and development company members—including BASF, Bayer CropScience, Dow AgroSciences, Dupont, FMC, Monsanto, Sumitomo and Syngenta—produce POP pesticides (Smith, 2001). This is not altruism; rather, it reflects technological and geographical shifts in pesticide manufacturing. The demand for the pesticides on the POP list has dropped significantly in the last few decades as many alternatives have become available and NGOs like PAN have targeted the "Dirty Dozen" in more than 50 countries (Fazal, 1987, p. xiii). Tellingly, the current Bush Administration has also supported implementing the current POPs ban, partly

> because the U.S. chemicals industry believes banning these first-generation pesticides and chemicals will "level the playing field" for export of more modern, profitable chemicals to foreign markets, especially in the developing world (The Center for International Environmental Law, 2004).[7]

Indeed, "[p]esticide regulation is widely recognised as having been beneficial to multinational companies in most respects: it has opened up markets for new high value added products when older, off-patent products are banned" (Tait, 2001, p. 67N).

If POPs are still manufactured, it occurs in developing countries. POPs remain relatively cheap to manufacture and their 17-year patents expired long ago (Dinham, 1993), meaning that small, independent companies often specialize in their production (Weir, 1987). This shift might have been a response to increased environmental regulation in industrialized countries.[8] Dinham (1993, p. 30) notes:

> An unintended impact of the controls … aimed at closing the 'circle of poison' … will almost certainly be the transfer of production facilities of these pesticides to Third World Countries, particularly if the market in those countries is sufficiently large. … In fact, much production has already shifted.

Thus, the POP pesticides "continue to be produced, used and stored in many countries" (Schafer et al., 2001, p. 9), but this is largely a situation in which trade and use originates in and ends in developing countries or regions, a situation substantially different from that described in *Circle of Poison*.

Manufacturing of non-POP pesticides has also shifted as European and U.S.

chemical companies have been aggressive in opening Third World markets (Weir, 1987, Wright, 1991). Pesticide use increased substantially in parts of Latin America, Asia, and Africa since the mid-1980s. To meet these expanding markets, "the multinational chemical companies—as well as a host of local imitators—have set up manufacturing and formulating facilities in practically every populated corner of the world" (Weir, 1987, p. 9). In 1984 alone, DuPont announced plans for pesticide plants in Indonesia and Thailand; Hoechst in Colombia, India, and Pakistan; Monsanto in Taiwan; and both Stauffer and Sandoz in Brazil (Weir, 1987). In the seven Central American countries there are now 42 pesticide formulating plants (Arbeláez and Henao H., 2002, p. 4). The local capitalist class owns many of the new formulating plants, which sometimes have weaker safety standards and controls than the transnational chemical companies (Weir, 1987).

In sum, information about the global geography of pesticide production suggests that the pesticides featured in *Circle of Poison*—especially the agrochemicals banned universally in industrialized nations—are no longer important to manufacturing firms in the United States or Europe, although they may still be produced by smaller manufacturers in developing countries. Non-POP pesticide production has also shifted partially to developing countries. I now examine pesticide exports from industrial countries to see whether the data corroborate this shift.

3.4. Pesticide Exports from Industrialized Nations

In the context of new international agreements and a shift of the production of older pesticides to developing countries, we would expect pesticide manufacturers in the industrialized nations to export fewer pesticides that are banned, severely restricted, or never registered in the countries of origin. This appears to be the case for European countries. As long ago as 1993, "European countries export[ed] only a small proportion of the pesticides on the PIC list" (Dinham, 1993, p. 183). Dinham (1993) also points out that in the 1980s and 1990s many of the PIC pesticides were made in India, Taiwan, and South Korea, with Taiwan being a prominent exporter since it does not participate in the PIC process.

The US no longer requires any agency to keep track of pesticide exports despite protests from critics, which include GAO. Summarized data are available only from the Foundation for Advancements in Science and Education, which has worked with US Customs statistics (FASE, 1998, Smith, 2001) to create relatively good data sets—"the best estimates possible" (Smith, 2001, p. 268)—concerning pesticide exports from US ports. Assuming that there are no serious and systematic biases,[9] these data allow for an analysis of the circle of poison's continued applicability to exports from the US.

Table 3 shows the export data. The total of banned, severely restricted, and never-registered pesticide exports drops from 3.4 to 1.6 percent and has not undergone major shifts in the nine years for which data are available. The export volumes of the separate categories comprising that total have changed, however, with a downward trend in the export of banned substances. In fact, the last year for which data are available shows no exports of banned pesticides. Exports of severely restricted pesticides have also decreased, though not as much as banned pesticides.

The increase in the export of pesticides that have never been registered in the US may offset the gains in reducing exports of banned and restricted pesticides. Scholars have not examined this specifically, but a Greenpeace report addresses it (Marquardt et al., 1992). It provides case studies of five pesticides—butachlor, carbosulfan, haloxyfop, nuarimol, and prothiofos—but does not reveal why these were selected or how representative they are of the never-registered pesticides produced in the US. For each pesticide, the report found that the manufacturers submitted petitions to EPA for tolerances to be established for the US food supply. All five of these were rejected due to health concerns. Manufacturers submitted petitions for registrations for crop use for three of the five pesticides, and EPA rejected each because of concerns over cancer, birth defects, residue problems, or injury to wildlife or fish.

While the amount of never-registered pesticide exports has increased and is problematic, the situation concerning the sum of banned, severely restricted, and never-registered products relative to total US pesticide exports has changed substantially. Figures from the 1970s and 1980s that 25 percent of all pesticide exports from the US were banned, severely restricted, or never-registered is very different from the best estimates of the current situation in which two percent of pesticide exports fall into that category (Table 3). Regarding the recent data, Smith (2001, p. 273) concludes, "efforts by the international community to reduce the trade in hazardous pesticides are bearing fruit. The fact that no export of any banned product was recorded in 2000 is particularly encouraging."

The circle of poison thus does not adequately describe the current pesticide export situation from industrialized countries. In the U.S. the percentage of banned, severely restricted, and never-registered pesticides has dropped by more than 10-fold—from 25 percent to two percent—from when the argument was first made. The circle of poison remains only somewhat relevant since the ethically problematic loophole for companies to export banned, restricted, and never-registered pesticides still exists in the U.S.

regulatory framework. Firms still exploit the loophole with the exportation of severely restricted and never-registered pesticides, which may be returning as undetected residues, but the overall importance of this description has dropped dramatically.

The first part of this paper has shown that there have been important shifts in global regulatory frameworks and the geography of production and trade of pesticides. The section below explores the other side: pesticide sales and use in developing countries.

4. Evaluating the Circle of Poison vis-à-vis Pesticide Sales and Use in Developing Countries

Detailed pesticide sales and use data are generally lacking, especially in developing countries. The available evidence suggests that in the 1980s other pesticides were replacing organochlorines in agro-export production in developing countries.

4.1. From Organochlorines to Organophosphates

Many changes occurred in global pesticide use since *Circle of Poison*. Based on fieldwork conducted in the early 1980s, Wright (1986, 1990) has argued that the circle of poison is a poor description of the types of pesticides used in developing countries.[10]

> The Mexican case demonstrates a disturbing aspect of the circle of poison diagnosis of Third World pesticide abuse problems. It appears that pesticide dumping is a very small part of the threat posed by Mexican pesticide use patterns. It is also clear that in responding to the concerns of North American consumers regarding the circle of poison, pesticide users in Mexico have adopted a new mix of dangerous chemical pesticides, mostly manufactured in Mexico but widely used in agriculture in developed and underdeveloped countries. The issues raised by this study suggest that the circle of poison perspective needs to be seriously reconsidered (Wright, 1986, p. 29).

Wright found that export farmers, in order to avoid rejections of produce at the border due to illegal residues of organochlorines that were banned in the US, switched from organochlorine insecticides to less residual but much more acutely toxic organophosphate and carbamate insecticides. This switch meant that food crops exported to the US had permitted residues and there was less use of very persistent pesticides. The shift, however, placed Mexican farmworkers in much greater danger of pesticide poisoning and death since organophosphate and carbamate insecticides, especially ones like parathion and aldicarb, are much more acutely toxic than organochlorines (Wright, 1986, 1990). Thus, Wright concludes that the circle of poison is inaccurate for a number of reasons, one important reason being that export farmers have shifted to pesticides allowed as residues on U.S. food, and this has meant greater endangerment of workers. A circle does not accurately describe the situation since it affects farmworkers in developing countries to a much greater extent than consumers in industrialized countries.

Other evidence from the late 1980s and early 1990s suggests that the trend identified in Mexico by Wright occurred elsewhere. Dinham's (1993) multi-country assessment showed that the organochlorines "are in less use," but that organophosphates and carbamates "are in common use and causing concern" (Dinham, 1993, p. 38). Grossman's research on pesticide use by banana producing households on St. Vincent adds evidence that export farmers used other highly toxic insecticides, not organochlorines, on export crops. His data from 37 household interviews in 1988 and 1989 (Grossman, 1998, p. 199, Table 7.2) reveal that of the eight most commonly used pesticides, six are organophosphates and carbamates. All but one of the commonly used chemicals are registered in the US, and none are dumped organochlorines. This shift from organochlorines to organophosphates occurred in the 1980s, so below I address whether further changes have occurred since this shift.

4.2. The Case of Costa Rican Vegetable Production

Initially it appears strange to use Costa Rica to make any conclusions about pesticide use in developing countries. Costa Rica enjoys an international reputation as the "green republic" because of the large proportion of the national territory in national parks (Evans, 1999). When it comes to pesticide use, however, Costa Rica is considerably less green than its neighbors. Indeed, it is an environmental exception in the opposite direction of its reputation: according to FAO (2004) data, Costa Rica's intensity of agricultural pesticide use (20.4 kilograms of active ingredient per cultivated hectare per year, or kg ai/ha/year) is the highest in Latin America—the most pesticide intensive world region—and the world, which averages 3.2 kg ai/cultivated ha/year.[11] Pesticides were introduced into Costa Rica in the 1940s and 1950s, and have become so widespread that most Costa Rican farmers—between 70 and 100 percent depending on the region—use only chemical methods of pest control (Farah, 1994, p. 33-4, Hilje Q. et al., 1987, Trivelato and Wesseling, 1992).

Costa Rica also featured very prominently in *Circle of Poison*. In addition to many examples involving exports to Costa Rica, the book's first case of banned pesticide dumping features DBCP, a nematicide made by Dow that was responsible for causing sterility in pesticide manufacturing workers and farmworkers. After the EPA banned DBCP in 1979, Amvac continued to export it to Costa Rica, Ecuador, and Honduras where the transnational banana company Standard Fruit, owned by multinational food corporation Castle & Cooke, continued to demand it and use it (Thrupp, 1991, Weir and Matthiessen, 1989, Weir and Schapiro, 1981). DBCP use in banana plantations after the US ban caused sterilization of an estimated 1,000 to 12,000 workers (Mora, 1997, p. 20, Weir and Matthiessen, 1989, p. 24).

4.2.1. International Regulatory Status of Pesticides in Northern Cartago and the Ujarrás Valley

I selected Northern Cartago and the Ujarrás Valley in Costa Rica as a specific locality in which to examine the circle of poison since farmers there produce vegetables for export and the national market. The data used below are from my survey of 148 vegetable farmers conducted in the study site during 2003 and 2004 (Galt, 2006). In addition to many other topics, information gathered in the survey included the names of pesticides used, as well as their dose and frequency of use.

As in many developing countries, Costa Rica does not have the resources to generate its own data to assess the risk of various pesticides (Thrupp, 1990), an important step in the pesticide registration process. Instead, Costa Rica relies upon registrations set in industrialized countries, especially the US. For example, the residues permitted for methamidophos in Costa Rica are almost precisely the same as those in the US.

This strategy makes sense given the primary importance of the US market to Costa Rican exporters, and the history of violations due to residues when exporting to the US. In the 1980s, the US came close to banning all Costa Rican beef exports because of high levels of DDT residues. “Immediately the local authorities banned the importation and use of DDT” (1988, p. 10). Thus, concern over the loss of foreign exchange earnings and the significant power of Costa Rican beef producers (cf. Edelman, 1995) who had little use for DDT changed Costa Rican pesticide registration.[12] A similar process occurred with aldicarb: despite numerous warnings of its very high toxicity, Costa Rican authorities did not ban its use until it caused violations of US residue limits on exported bananas (Dinham, 1993, p. 103). These examples suggest that we might expect similarities between pesticides registered in Costa Rica and the US.

To examine the applicability of the circle of poison to pesticides used in Costa Rica, one has to decide on a reference point of what constitutes a pesticide that fits the circle of poison description. A single country, an array of industrialized countries, or the PIC and POPs lists discussed above are all potentially valid reference points. A comparison of the PIC and POPs list with those pesticides used in Northern Cartago and the Ujarrás Valley suggests that the circle of poison argument is largely not applicable. Table 4 shows the number and percentage of active ingredients (ai's) included on the PIC list. Only two ai's out of a total of 122, or 1.6 percent, are on the PIC list, and these are on the side of the list requiring notification for only for certain formulations. One is methamidophos, which is highly toxic and relatively widely used in the study site and also in the US, Canada, and Germany. It is, however, banned in Libya, Indonesia, and Kuwait, severely restricted in Sri Lanka, and restricted in nine other countries (Orme and Kegley, 2004). The other is methyl-parathion, which is rarely used by a few farmers in the study site. This pesticide can be used without restriction in the US, Germany, and the Netherlands, but Denmark, Finland, Portugal, the UK, and many developing countries do not allow its use. Regarding the POPs list as a reference point, none of the 122 ai's used in the study site are on the list (Table 4). This means that farmers in the area are not using the older, environmentally persistent pesticides that were the main focus of *Circle of Poison* and are targeted in international agreements.

It is also possible to use a specific industrialized country, or a group of industrialized countries, as the reference point. One problem with the circle of poison conceptualization is that it implicitly assumes that there is a general consensus between industrialized countries about which pesticides should be banned or restricted. As the examples of methamidophos and methyl-parathion above demonstrate, this is a very questionable assumption when applied to newer pesticides that are not on the POPs list. Thus, a selection of industrialized countries as a reference point may be more appropriate than international lists. I selected the United States, Canada, Denmark, the Netherlands, and the United Kingdom for the sample of industrialized countries because they represent some diversity of cultural and regulatory traditions. Table 4 shows the number of pesticides used in Northern Cartago and the Ujarrás Valley that are registered or restricted in some way in these countries. Using the US as a reference point, we see that 91 ai's (74 percent) are registered for use in the US, none are banned, and none are restricted. It also means that 31 ai's are not registered in the US and it is unknown whether these failed registration or it was never attempted.[13] The penultimate column in Table 4 represents the reference point of banned, severely restricted, or restricted in at least one country in the PAN database, a very broad category. Forty-three ai's, or 35 percent, fall into the category. While this number could be emphasized to show the circle of poison's applicability to the situation in Costa Rica, it would likely be a similar percentage for pesticides used in the US since pesticide used as standards—like mancozeb, maneb, chlorothalonil, atrazine, alachlor, methomyl, and methamidophos—have all been banned or restricted in other industrialized countries. The final column in Table 4 shows the converse of the previous column: those pesticides not registered in any industrialized country. With this reference point, only four of the 122 ai's are included. In other words, at least one industrialized country has decided that 118 of these ai's can be used within its borders for agricultural purposes.

Comparing the regulatory status of pesticides used in Costa Rica across industrialized countries reveals that industrialized countries make different pesticide regulation decisions. With pesticides other than the older organochlorine pesticides that dominate the POPs list, scientific findings and health and environmental considerations are not the only factors driving pesticide regulation. Instead, political, economic, environmental, and agricultural factors at the national level are influential. Specifically, the influence of the chemical industry over regulators; the relative power and actions of various groups involved in pesticide regulation, such as farmers, farmworkers, activists, health professionals, and industry lobbyists; the different requirements of evidence of harm and burden of proof, including the differential application of the precautionary principle (Tait, 2001); the size of the market for a specific pesticide; climatic and environmental factors; the specific mix of crops grown in a country; and pest presence and absence are potentially important factors influencing pesticide regulatory outcomes. For example, much important literature exists on the politics of pesticide regulation in the US (Graham, 1970, Hynes, 1989), showing that regulatory decisions about pesticides are inadequate in many ways vis-à-vis protecting human health (Wargo, 1998) and strongly shaped by the corporations they are meant to regulate (Fagin et al., 1999, Powell, 1999, van den Bosch, 1980). Thus, US pesticide regulations—and those of any industrialized country or group of industrialized countries—cannot be considered a proxy for safety since problematic agrochemicals often remain registered.

Circle of poison thinking is therefore flawed because it assumes that the regulatory status of pesticides in industrialized countries is a valid proxy for the safety of a pesticide. When one says, "Pesticide X is banned in the US" it implies that the pesticide is very unsafe or environmentally damaging, which, indeed, is often the case.

But it also implies the converse as a corollary, that pesticides registered for use in the US are safe and not environmentally damaging, which is clearly not the case with many pesticides. Wargo (1998, p. 5) points to the hazards of the nearly 325 pesticide active ingredients registered in the US: "Nearly one-third of these 'food-use' pesticides are suspected of playing some role in causing cancer in laboratory animals, another one-third may disrupt the human nervous system, and still another third are suspected of interfering with the endocrine system."

Thus, we should rely on a system of judging pesticide hazards and safety based on health and environmental effects rather than using regulations in industrialized countries as their proxy. While others could be developed, the Pesticide Action Network's (PAN) Bad Actor pesticide categorization system provides such a reference point. A pesticide qualifies as a Bad Actor if it is any of the following: highly acute toxic according to the World Health Organization (WHO), EPA, or the US National Toxicology Program; a known or probable carcinogen according to EPA; a reproductive or developmental toxin listed in California's Proposition 65; a cholinesterase inhibitor according to the Material Safety Data Sheet (MSDS), the California Department of Pesticide Regulation, or the PAN staff's evaluation of chemical structure; or a known groundwater contaminant (Orme and Kegley, 2004). Table 5 applies this categorization to the pesticides used in Northern Cartago and the Ujarrás Valley. Compared to Table 4, the information is much more relevant for helping to understand the health and environmental risks from pesticides. Additionally, once analysis progresses beyond the use of industrialized country regulations as proxies for safety, the direct comparison of the hazards of pesticides used in developing countries and industrialized countries—prevented by circle of poison thinking—becomes possible, thereby allowing for a political ecology of pesticides that breaks through the problematic first/third world dichotomy (Emery and Pierce, 2005, McCarthy, 2002, St. Martin, 2005). The problem that remains is that data for this type of comparison is extremely limited in most countries.[14]

4.2.2. Pesticide Use on Export Crops: Updating Wright's Revision of the Circle of Poison

The last link in the circle of poison to be analyzed here is the use of banned, restricted, and never-registered pesticides on export crops grown in developing countries for markets in industrialized countries. The data used in this section focuses on insecticide use on export vegetables grown in Costa Rica in 2003-04. Exporters in the area emphasize the need for their farmers to rationalize pesticide use and to use pyrethroids and other less residual insecticides during harvest time rather than organophosphates and carbamates since these have caused rejections of produce shipments in the recent past because of illegal residues (Galt, 2007). Pyrethroids are broad-spectrum insecticides that are applied at much lower doses per hectare than the older organophosphate, carbamate, and organochlorine pesticides. They are modeled after pyrethrum, a naturally occurring pesticide in chrysanthemum flowers, but they are synthetic pesticides, some of which are possible carcinogens and suspected endocrine disruptors (Table 6). They are generally less acutely toxic to mammals than organophosphates and carbamates. The average LD_{50} (lethal dose for half of the animal test population) for the commonly used pyrethroids in the area is 1343 mg/kg, while it is 465 mg/kg for organophosphates and 13 mg/kg for carbamates (Table 6). Pyrethroids are not cholinesterase inhibitors, which from a worker and farmer health perspective is a significant advantage over organophosphates and carbamates since it means they are less likely to cause neurological impairment and poisoning. Their relatively rapid breakdown also means less risk upon re-entry of the field a day or two after application, in comparison to the typically more persistent organophosphates and carbamates. They are, however, quite toxic to much aquatic life (Tait, 2001), and their broad-spectrum action means that biological control through beneficial insects is not compatible with their use.

Table 7 shows the use of insecticides by chemical class on the three main export crops in the study site, chayote, green beans, and mini-squash. Organophosphate and carbamate insecticides do not dominate insecticide applications for these export crops. Instead, pyrethroids constitute a much greater percentage of the total insecticide doses, and there is also reliance on newer classes of synthetic insecticides and bioinsecticides.[15] Thus, another shift in insecticide classes appears to have occurred since Wright's fieldwork: some export farmers have replaced heavy reliance on organophosphate and carbamate insecticides with a heavy reliance on pyrethroid insecticides, and many now incorporate newer classes of insecticides and bioinsecticides like botanicals, microbials, and soaps. Many export farmers still use organophosphate and carbamate insecticides, but for the most part export farmers in Northern Cartago and the Ujarrás Valley use them in the pre-planting and developmental stages and not close to harvest in order to avoid residue problems.

4.3. Organophosphate Use in Other Areas

Recent but limited global insecticide market data suggest the same trend as the Costa Rican data that organophosphates and carbamates are declining in importance. They accounted for 71 percent of sales of the top 100 insecticides in 1987, but were down to 52 percent in 1999 (Nauen and Bretschneider, 2002, p. 241). From 1987 to 1997, the use of many other types of insecticides, including pyrethroids and many with newer modes of action, increased and made up for this decline (Nauen et al., 2001). The decline in the importance of the organophosphates is illustrated by the fact that imidacloprid, a neonicotinoid insecticide (a relatively new class), is now the top selling insecticide worldwide (Nauen et al., 2001).[16] The partial replacement of organophosphates and carbamates with newer insecticides is due to increased insect resistance, the need for agrochemical companies to sell newer pesticides as patents on older ones expire, and stronger scrutiny of their effects. In the U.S., the passage of the Food Quality Protection Act in 1996 specifically targeted these pesticides with relatively tough reregistration standards, prompting concern over their possible withdrawal in the near future (Winter, 1998) and the adoption of alternatives (Warner, 2007).

This moderate global shift away from organophosphates and carbamates has occurred in other locales. Between 1984 and 1998, major shifts occurred in organophosphate and pyrethroid use in New Zealand. By 1998, organophosphate use decreased by more than half compared to the mid-1980s because of changing horticultural insect control practices and the end of treating pasture with insecticides. During the same time, pyrethroid use increased seven-fold from a small base (Holland and Rahman, 1999, p. 14). U.S. cotton production experienced the same shift away from organophosphates as pests built up resistance to them (Benbrook et al., 1996). The shift to pyrethroids and other insecticides with newer modes of action in cotton resulted in a rapid decline in insecticide application rates from the early 1970s (Fernandez-Cornejo et al., 1998, p. 463-4). In California, certain commodity sectors which engaged in agroecological partnerships through the Biologically Integrated Orchard Systems (BIOS) projects in recent decades—most notably almonds, pears, and wine grapes—succeeded in reducing organophosphate and carbamate use through substitution of various alternative cultural and IPM practices and pyrethroids (Warner, 2007). Similar shifts have likely occurred in developing countries in addition to Costa Rica as pests develop resistance to the older organophosphates and carbamates, yet there is scant data from which to draw conclusions. The shift evident in the Costa Rican export sectors discussed above appears, however, to be part of a more widespread, moderate global shift that has been documented in other areas.

The shift away from organophosphates might not be universal, however, gauging by limited data from other studies of pesticide use in developing countries (Table 8). In 2003, Dasgupta et al. (2007, p. 93) surveyed pesticide use among 820 farmers in Bangladesh, where pesticide use has more than doubled between 1992 and 2001 and where pesticide sales firms continue to sell the older pesticides on the POPs list. All farmers surveyed grew rice and vegetables and other crops, including, potato, bean, eggplant, cabbage, sugarcane and mango. They rely most heavily on insecticides, with most farmers spraying 4 times during a season. Their pesticide use indicates that the largest number of insecticides came from the organophosphates and carbamates classes, followed by pyrethroids and then organochlorines. Similarly, a survey of 61 farmers in northern Tanzania showed the same rank, but far fewer numbers of organophosphates and organochlorines (Ngowi et al., 2007). From these lists alone, however, it is difficult to rank these pesticide families by actual use, as a larger number of active ingredients in one chemical class does not necessarily mean that they are used more often.[17] The last column from provides the same list from my survey data in Costa Rica and shows proportions similar to both countries. In the case of Costa Rica, this simple listing masks the high reliance on pyrethroids described above since these insecticides are used much more frequently than the organophosphates on the list. This could be the case in Tanzania and Bangladesh, yet the authors do not present this data.

Comparing data from vegetable production in Bangladesh, Costa Rica, and Tanzania suggests that countries producing vegetables for the US and European export markets (Costa Rica and Tanzania, respectively) have lower use of POPs and PIC list pesticides compared with those that are not highly integrated into those markets (Bangladesh). However, the extent and geographical patchiness in shifts in pesticide use, especially their relation to the export and national market, needs to be better explored by future research.

5. Conclusion

This paper shows that, despite its persistence in some academic circles and in popular understanding, the circle of poison inaccurately describes the global pesticide complex. Reforms aimed at changing the situation described by the circle of poison conceptualization effectively changed global pesticide regulation with the eventual adoption of PIC and the POPs treaty. In the way of the double hermeneutic (Giddens, 1987) and like Polanyi's (Polanyi, 1957) "double movement," society's understanding of the circle of poison spurred important social action which helped render it an inadequate characterization of today's global pesticide complex. Other processes have helped render the circle of poison obsolete, including ecological changes such as pest resistance to older pesticides, and the imperative of capital accumulation, which, partnered with limited patent lives, means that large agrochemical companies constantly develop and promote newer pesticides around the world.

This double hermeneutical process has, however, still not fully succeeded in stopping the export of never-registered pesticides from industrialized countries, a potentially problematic practice. It would be common sense for EPA at a minimum to require risk assessments for non-registered pesticides manufactured in the US since formulation workers here are exposed to it and there are risks of accidental environmental contamination and exposure to the US population through the environment or residues on food. Since importing developing countries often do not have the resources to conduct risk assessments on their own (Thrupp, 1990), making these risk assessments available to importing countries is an ethical necessity, but not one that occurs since EPA does not demand it. The changes effected by activism offers hope that a large role remains for environmental groups to play in pressuring for farmworker rights, especially vis-à-vis pesticides, so as to reduce and eliminate acute and long-term health risks from pesticide exposure. Organophosphates and carbamates still pose an extremely large hazard to farmworkers, farmers, and rural residents. Because of the acute hazards they pose, they should be the renewed focus of PIC and worldwide and local efforts to reduce their use.

From the above evidence, I propose a two-part conceptualization of pesticide use in developing countries—called "pesticide divergence by market orientation"—to replace the circle of poison. Part one concerns partial convergence between core and periphery: as export sectors in developing countries that provision industrialized countries increasingly face public and private regulation from afar (Barrett et al., 1999, Galt, 2007), we should expect increased similarities in pesticide use between these export sectors and the same sectors in industrialized countries. Just as 30 percent of pesticide usage in Europe is specified by contracts with food processors and supermarkets (Tait, 2001, p. 67N), these export sectors often involve similar types of contracts and control mechanisms. Basically, *pesticide use in industrialized countries and export production in developing countries are no longer worlds apart as suggested in circle of poison thinking*. As outlined by Schroeder et al. (2006, p. 167) and the contributors to first world political ecology, in developing countries "both core and periphery are simultaneously present." These export sectors, as the ones described by Wright (1986) in Mexico and above in Costa Rica, likely use pesticides that are the same as and similar to those used in most industrialized countries since they are subject to the same regulatory standards vis-à-vis residue testing. Importantly, this does not mean that this pesticide use is "safe" since most pesticides registered for general use in industrialized countries pose significant and varied hazards to farmworkers, farmers, rural residents, the environment, and perhaps consumers. This is especially true of the continued use of acutely toxic organophosphate and carbamate insecticides in both developing and industrialized countries. Using the Bad Actor or similar classification will allow for direct comparisons and move analysis beyond the problematic use of regulation in the global North as a proxy for safety and the third world/first world binary generally.

Part two of the new conceptualization concerns continued difference between core and periphery: with the shift in manufacturing of many of the POPs and PIC pesticides to developing countries, if they remain in use, I argue that their use remains mostly restricted to crops produced entirely for the national market, as these are not typically subject to strong pesticide residue regulations (Galt, in review). This suggests *within-country divergence in developing countries according to market segment*, i.e., pesticide use in the more regulated export segment will be different than pesticide use in the less regulated domestic segment. Thus, one of the problematic parts of the global pesticide complex—the manufacturing, trade, and use of most organochlorine pesticides featured in *Silent Spring* and *Circle of Poison*—exists almost entirely within the developing world and is little impacted by international agreements or pesticide standards in the global North. These notorious pesticides cause harm to farmworkers, farmers, and other citizens of developing countries, and, importantly, *do not* return to consumers in industrialized countries as residues on food since they are not used on export crops.

I see two opportunities for future research. The first is to bring other countries and locales into our knowledge of the global pesticide complex, especially areas more on the periphery than Costa Rica and Mexico, with more attention paid to market relations and segmentation—i.e., export markets, controlled national market channels like supermarkets, and less-controlled national market channels like farmers' markets—and how they may influence pesticide use. Work reviewed above in Tanzania (Ngowi et al., 2007) and Bangladesh (Dasgupta, 2007) and a recent farmer survey conducted in 26 countries allows for some potential comparisons (Matthews, 2008), but these publications do not reveal the intensity of pesticide use, nor details on the types of pesticides used and their relationship to production aimed at the national and export markets. Comparative international work attentive to political economic relationships will allow for better understandings of the factors that impact national level pesticide regimes, and also to identify those countries and areas where the most problematic pesticide use remains so that alternatives can be promoted. Data collection needs to progress beyond generating lists of pesticides used and into the more difficult terrain of gathering information on intensity of use as determined by frequency, dose, etc.

Second, we will continually need empirical and theoretical work to understand shifts over time in the geography of pesticide regulation, production, trade, sales, and use into the future. Even with limited data available, examining changes in the global pesticide complex in the last three decades suggests that change occurs rather rapidly due to a number of processes. These include environmental politics informed by public concerns (Buttel, 2003, Tait, 2001), trade liberalization (Dasgupta et al., 2001), global climate change, pest invasions, the pest resistance to pesticides, rapid changes in food commodity prices, technical developments in the pesticide industry (Fernandez-Cornejo et al., 1998), and the adoption of more sustainable production methods (Wargo, 1998). Thus, we must frequently revise our understandings of the global pesticide complex due to the dynamism of the underlying social, economic, and ecological processes that shape it. Furthermore, this future work can tease out the relative weights of various processes to explain shifts in the global pesticide complex and in specific locations.

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[1] GAO has been renamed the Government Accountability Office.

[2] In combining these concerns, Weir and Schapiro's book is arguably an overlooked work in the cannon of political ecology and can sit comfortably next to work by Blaikie and Brookfield (Blaikie and Brookfield, 1987) and others forging political ecology at the time (Bunker, 1985, Hecht, 1985, Watts, 1983).

[3] The circle of poison framework also implicitly informs recent work in the biophysical sciences. For example, Daly et al. (2007) recently examined the existence of organochlorine pesticides in the atmosphere and soils of Costa Rica, while Klemens et al. (2003) examined their presence in various animal taxa in northwestern Costa Rica. The continued focus on the organochlorines in environmental science studies in developing countries often assumes their active and continued use. If the authors note the existence of national legislation banning them, they often assume that farmers skirt these regulations.

[4] Duram does not discuss the possibility that many of these banned pesticides are persistent organic pollutants (POPs) that remain in soil for decades after their use. A detailed analysis of residues in imported and domestic produce in the US "failed to support the popular stereotype [derived from the circle of poison argument] that imported foods are more likely to be contaminated" (Groth et al., 2000, p. 9). For example, 4.2 percent of tested winter squash produced in Mexico had dieldrin residues, while 35 percent of it produced in the US showed dieldrin, and residue levels were significantly greater in US squash. The opposite is true in the case of carrots from Canada and the US.

While 74 percent of Canadian samples had DDT residues, only 6.4 percent of US carrots had DDT residues (Groth et al. 2000, cited in Schafer et al., 2001, p. 11). In these cases, it is likely that these residues in food exist because of the persistence of the agrochemicals in the soil, not their current agricultural use.

[5] PIC is now shorthand for the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.

[6] These synthetic organochlorines are created by combining elements—hydrogen, carbon, and chlorine—into new compounds that had never before existed. Persistence varies from half-lives of a year for some of the fastest degrading ones, to 21 billion years for 1,2-dichloroethylene (Thornton, 2000, p. 33, cited in Johansen, 2003, p. 16).

[7] While the administration has supported the current ban, it has opposed the essential international "adding mechanism" that would allow for more chemicals to be added in the future should new evidence indicate that they pose a threat (The Center for International Environmental Law, 2004).

[8] Caution should be used in making this argument, as environmental regulations typically are a very small percentage of total production costs. Manufacturing employment has certainly declined in the US and other industrialized countries, but the overwhelming reason for the shift is savings on labor costs, not to avoid environmental regulation (Goodstein, 1994, Roberts and Thanos, 2003).

[9] There are limitations to this data. The authors had to depend on the export records of the Port Import Export Reporting Service from the *Journal of Commerce*. With Smith's study it was possible to only identify 46 percent (by volume) of the shipments during the study period due to the prevalence of inadequate descriptions such as "organophosphate

insecticide" and "weed killing compound" (Smith, 2001, p. 268). Unfortunately, Smith does not address whether the inadequate descriptions may be attempts of companies to hide the true nature of shipments. This is certainly a possibility, but it is impossible to determine the extent to which this occurs.

[10] As with *Circle of Poison*, Wright's work is much broader than the portion represented in this paper. Most of his analysis, especially the importance of the social relations of production in pesticide poisoning cases, remains very relevant.

[11] Most country-level pesticide intensity data is based upon total purchases in that country divided by total cultivated land, rather than data about use. Use data are almost entirely nonexistent at the national level, so even though pesticide sales data may poorly reflect use patterns, they are the only data available (Chaverri, 1999, Chaverri and Blanco, 2002).

[12] State agencies still use DDT for mosquito control.

[13] The Greenpeace report shows that at least two of the pesticides used in Northern Cartago and the Ujarrás Valley, haloxyfop and prothiofos, failed to gain tolerances, and one of these, haloxyfop, failed the registration attempt (Marquardt et al., 1992). Only two of the 31 are included in the Greenpeace report, and considerable effort would be needed to determine whether the 29 others failed registration and/or tolerance setting by EPA.

[14] Using data from Kegley et al. (2000) and my farmer survey allows for a cursory comparison of California and Costa Rica. Using the pesticide database provided by PAN (Orme and Kegley, 2004), it was determined that 60 of the 122 (or 49 percent of) active ingredients used in the Costa Rican study site are Bad Actor pesticides. Of the

commonly used pesticides in California identified by Kegley et al. (2000, p. 73-84), 66 percent are Bad Actor pesticides. Further and more detailed comparisons could be made, but this cursory comparison reveals the problem of remaining trapped in circle of poison thinking.

[15] Only one export chayote, green bean, or mini-squash farmer in the survey sample reported using an organochlorine insecticide. This is endosulfan, which is not on the PIC or POPs list, is registered and used in the US (EPA, , 2006), and has an EPA tolerance for summer squash (EPA, , 2004). Being legal in the US does not mean that it is safe, since endosulfan is quite toxic, a suspected endocrine disruptor, and very highly toxic to aquatic organisms (Orme and Kegley, 2004).

[16] Some have implicated this pesticide in recent bee colony declines (Bonmatin et al., 2005).

[17] The Bangladesh work does report mean number of applications per pesticide, but the Tanzanian work does not. Without further details as to which crops are sprayed with which pesticides, it is impossible to work out proportions of doses as in Table 7 above.

Table 1: Chemicals on the Prior Informed Consent (PIC) List

Included on PIC List	Candidates
Pesticides in Any Formulation	
2,4,5-T and its salts and esters	aldicarb
aldrin	alachlor
binapacryl	carbaryl
captafol	methyl parathion
chlordane	mirex
chlordimeform	
chlorobenzilate	
DDT	
dieldrin	
dinitro-ortho-cresol (DNOC) and its salts	
dinoseb and its salts	
EDB (1,2-dibromoethane)	
ethylene dichloride	
ethylene oxide	
fluoroacetamide	
HCH (mixed isomers)	
heptachlor	
hexachlorobenzene	
lindane	
mercury compounds including inorganic mercury compounds, alkyl mercury compounds and alkyloxyalkyl and aryl mercury compounds	
monocrotophos	
parathion	
pentachlorophenol and its salts and esters	
toxaphene	
Pesticides in Certain Formulations	
dustable powder formulations containing a combination of benomyl at or above 7%, carbofuran at or above 10%, and thiram at or above 15%	
methamidophos (soluble liquid formulations of the substance that exceed 600 g active ingredient/l)	
methyl-parathion (emulsifiable concentrates (EC) at or above 19.5% active ingredient and dusts at or above 1.5% active ingredient)	
phosphamidon (Soluble liquid formulations of the substance that exceed 1000 g active ingredient/l)	
Industrial Chemicals and Minerals	
actinolite asbestos	chrysotile asbestos
amosite asbestos	
anthophyllite asbestos	
crocidolite asbestos	
polybrominated biphenyls (PBB)	
polychlorinated biphenyls (PCB)	
polychlorinated terphenyls (PCT)	
tetraethyl lead and tetramethyl lead	
tremolite asbestos	
tris (2,3 dibromopropyl) phosphate	

Source: UNEP and FAO, 2008: Annex III.

Table 2: Chemicals on the Persistent Organic Pollutants (POPs) List

Pesticides	Other Chemicals
aldrin	dioxins (PCDDs)
chlordane	furans (PCDFs)
DDT	polychlorinated
dieldrin	byphenyls (PCBs)
endrin	
heptachlor	
hexachlorobenzene	
mirex	
toxaphene	

Source: UNEP, 2008.

Table 3: Banned, Severely Restricted, and Never-Registered Pesticide Exports from US Ports, 1992-2000 (in Millions of Pounds)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Banned	5.93	4.90	8.54	6.50	5.14	2.32	1.45	1.07	0
Severely restricted	6.15	8.32	4.60	5.87	5.82	7.58	4.42	3.15	4.65
Never-registered	4.54	2.47	2.97	5.83	5.52	10.52	7.17	11.31	11.23
Subtotal	16.62	15.70	16.11	18.20	16.49	20.42	13.04	15.53	15.88
Total pesticide exports	490.11	486.14	526.17	630.04	687.60	786.54	812.02	831.26	761.89
Percent banned, severely restricted, and never-registered of total	3.4%	3.2%	3.1%	2.9%	2.4%	2.6%	1.6%	1.9%	2.1%

Sources: FASE, 1998, p. 4 and Smith, 2001, p. 268.

Table 4: International Regulatory Status of 122 Pesticides Used in Northern Cartago and the Ujarrás Valley

	PIC List	POP List	US	Canada	Denmark	Netherlands	UK	Banned or restricted somewhere	Registered in one industrialized country
			Selected Industrialized Countries						
Banned/restricted									
# of ai's	2	0	0	3	11	3	2	43	—
% of ai's	1.6%	0%	0%	2.5%	9.0%	2.5%	1.6%	35.2%	—
Registered									
# of ai's	—	—	91	69	50	56	74	—	118
% of ai's	—	—	74.6%	56.6%	41.0%	45.9%	60.7%	—	96.72%

Sources: Author's farmer surveys, 2003-04; regulatory information from Orme and Kegley, 2004.

Table 5: PAN's Bad Actor Classification Applied to Pesticides Used in Northern Cartago and the Ujarrás Valley

	PAN Bad Actor Pesticide	Highly or Very Highly Toxic	EPA Known or Probable Carcinogen	Cholinesterase Inhibiting Neurotoxin	Known Groundwater Contaminant	Developmental or Reproductive Toxicant	Suspected Endocrine Disrupter
# of ai's	60	18	19	22	3	25	26
% of ai's	49.2%	14.8%	15.6%	18.0%	2.5%	20.5%	21.3%

Sources: Author's farmer surveys, 2003-04; Bad Actor information from Orme and Kegley, 2004.

Table 6: Toxicity Information for Foliar Insecticides Commonly Used in Northern Cartago and the Ujarrás Valley

Active Ingredient	Toxicity Class	Oral LD_{50} (mg/kg)	Carcinogen	Cholinesterase Inhibitor	Reproductive or Developmental Toxin	Endocrine Disruptor	Groundwater Contaminant	PAN Bad Actor	EPA Registration
Carbamates									
carbofuran	Ib	5	not likely	yes	?	?	potential	yes	yes
methomyl	Ib	17-24	not likely	yes	?	suspected	potential	yes	yes
	Average:	12.75							
Organophosphates									
chlorpyrifos	II	135-163	not likely	yes	?	suspected	?	yes	yes
diazinon	II	300-400	not likely	yes	yes	?	potential	yes	yes
dimethoate	II	290-325	possible (EPA)	yes	yes	?	potential	yes	yes
methamidophos	Ib	20	not likely	yes	?	?	potential	yes	yes
prothiofos	II	1500	?	yes	?	?	?	yes	no
	Average:	465.3							
Organochlorines									
endosulfan	II	70	not likely	no	?	suspected	?	yes	yes
	Average:	70							
Pyrethroids									
cyfluthrin	II	869-1271	not likely	no	?	?	?	no	yes
cypermethrin	II	247	possible (EPA)	no	?	?	?	no	yes
deltamethrin	IV	128-5000	unclassifiable	no	?	?	?	no	yes
lambda-cyhalothrin	II	56-79	unclassifiable	no	?	suspected	?	no	yes
permethrin	II, IV	4000	possible (EPA)	no	?	suspected	?	no	yes
z-cypermethrin	II	86-134	possible (EPA)	no	?	suspected	?	yes	yes
	Average:	1343.1							
Benzoifenils, Benzoylureas, Pyrrols, & Neonicotinoids (Synthetic Insecticides with New Modes of Action)									
chlorfenapyr	II	626	possible (EPA)	no	?	?	?	no	yes
diflubenzuron	III	4640	not likely	no	?	?	?	no	yes
imidacloprid	III	450	not likely	no	?	?	potential	no	yes
novaluron	IV	> 5000	not likely	no	?	?	?	no	yes
teflubenzuron	IV	> 5000	?	no	?	?	?	no	no
thiamethoxam	IV	1563	likely (EPA)	no	?	?	?	yes	yes
	Average:	2913.3							
Botanical, Microbial, & Organic Insecticides									
avermectin	II	10	not likely	no	yes	?	?	yes	yes
Bacillus thuringiensis	IV	> 5000	?	no	?	?	?	no	yes
potassium salt	IV	> 5000	?	no	?	?	?	no	yes
spinosad	IV	3738	not likely	no	?	?	?	no	yes
	Average:	3437							

Sources: Author's farmer survey, 2003-04; EPA, 2006 and IRET, 1999 for LD_{50}; Orme and Kegley, 2004 for other information.

Table 7: Insecticide Classes Used on Export Vegetables, Northern Cartago and the Ujarrás Valley

	Chayote (n=20)	Green Beans (n=11)	Mini-squash (n=28)[a]	Total
Pyrethroids	63.5%	55.0%	37.9%	56.9%
Organophosphates & Carbamates	18.4%	17.8%	16.7%	18.0%
Synthetic Insecticides with New Modes of Action	12.5%	3.9%	18.5%	13.5%
Botanical, Microbial, & Organics	1.0%	17.1%	21.4%	6.8%
Organochlorines	0.6%	0.0%	0.0%	0.2%

[a] Farmers contribute two to the sample size if they grow both mini-scallop squash and mini-zucchini.

Source: Author's farmer surveys, 2003-04.

Table 8: Insecticide Classes Used in Vegetable Production in Bangladesh, Tanzania, & Costa Rica

	Number of active ingredients used		
	Bangladesh (n=820)[a]	Tanzania (n=61)[b]	Costa Rica (n=148)[c]
Pyrethroids	6	4	9
Organophosphates & Carbamates	19	8	22
Synthetic Insecticides with New and Other Modes of Action	2	0	14
Botanical, Microbial, & Organics	1	2	6
Organochlorines	5	1	1
PIC list (listed /some formulations listed / candidate)	3 / 2 / 1	0 / 0 / 0	0 / 2 / 0
POPs list	2	0	0

[a] Dasgupta et al., 2007: 112.
[b] Ngowi et al., 2007: 1620.
[c] Author's farmer surveys, 2003-04.