Pesticide Exports from U.S. Ports, 2001–2003

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Analysis of U.S. Custom Service shipping records for the years 2001-2003 indicates that nearly 1.7 billion pounds of pesticide products were exported from U.S. ports, a rate of more than 32 tons per hour. Included in this total were nearly 28 million pounds of pesticides whose use is forbidden in the U.S. WHO Class 1a and 1b pesticides were exported at an average rate of more than 16 tons per day. More than half a billion pounds of pesticides known or suspected to cause cancer were exported during this period, with the majority of these shipments going to developing countries; pesticides associated with endocrine disruption were exported at an average rate of more than 100 tons per day. Although the rate of export of banned products declined, as did exports of pesticides included in the Rotterdam Convention on Prior Informed Consent (PIC) and the Stockholm Convention on Persistent Organic Pollutions (POPs), substantial quantities of hazardous products remain in trade. These products pose unacceptable risks in countries where unsafe use and storage practices are prevalent, and where women and children account for a large percentage of the agricultural workforce. Given the historically slow pace of regulatory reform, it is urgent that policy makers, growers, and scientists undertake more aggressive efforts to foster truly sustainable agricultural practices on a global scale. *Key words*: pesticides, international aspects, endocrine disruptors, Rotterdam Convention, Stockholm convention

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Among synthetic chemicals, pesticides are unique: they are released into the environment *because* they are hazardous to life forms. Concern regarding the adverse health and environmental effects caused by these intentional toxic releases has been a significant force in the growth of the global environmental movement and has added urgency to national and international efforts to regulate chemicals.

Low levels of pesticide residues and metabolites can now be detected in food, water, and human tissue throughout the world, but a surprising percentage of all persons now living on earth experience much more substantial exposure to pesticides. The agricultural labor force accounts for approximately 22% of the world's population, and half of the world's total labor force.[1] Forty-three percent of these workers are women.[2] Seventy percent of all child laborers, a total of 170 million children, work in agriculture.[3]

In many parts of the world, these workers are denied fundamental human rights such as freedom of association and the right to organize and collectively bargain with employers.[3] Despite conservative estimates of 300,000–400,000 deaths each year from pesticide poisoning in Southeast Asia and the Western Pacific, and tens of millions of poisoning incidents in the developing world, medical resources for exposure victims are scarce and very little is being done to effectively identify appropriate treatments or antidotes.[4–6]

REGULATORY BACKGROUND

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)[7] "represents one of the earliest domestic efforts in the U.S. to control the exchange of chemicals in international commerce."[8] It was enacted in 1947, and subsequently amended by the Federal Environmental Pesticide Control Act (FEPCA) of 1972, and again by the Food Quality Protection Act (FQPA) of 1996.[9] FIFRA requires the the agency charged with its administration, the U.S. Environmental Protection Agency (EPA), to "regulate the use and sale of pesticides to protect human health and preserve the environment."[9]

Two domestic regulatory schemes govern the export of pesticides. The first applies to pesticides registered for use within the United States. EPA regulates the domestic use of pesticides according to their their degree of risk to humans and the environment, and has authority over pesticide labeling, use, transport, and storage.

The second regulatory scheme applies to exported pesticides. If a pesticide is not registered for use in the United States,[10] it can nevertheless be manufactured and exported, so long as the exporters comply with labeling and notification requirements defined under FIFRA Section 17(a).[10] Labels must include the pesticide producing establishment's EPA-assigned number, as well as warning or caution statements "adequate for the protection of persons handling the pesticide, device or active ingredients including warnings regarding general toxicological hazards and environmental, physical or chemical hazards."[11] Warnings or caution statements must be provided in both English and appropriate foreign languages.[11] In addition, labels for

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exported pesticides not registered for use in the United States must include the statement "Not Registered for Use in the United States of America."[11] Despite these requirements, producers of unregistered pesticides are able export the chemicals without adhering exactly to the labeling requirements of section 17(a)(1). Specifically, the EPA allows exporters to satisfy Section 17(a)(1) labeling requirements "by placing supplemental labeling on shipping containers instead of on the product container."[8,10]

Exporters of unregistered pesticides must also comply with FIFRA's notification requirement, which reads as follows:

> Section 17(a)(2) provides that any person exporting a pesticide other than a pesticide registered for use under FIFRA section 3 or sold under FIFRA section 6(a)(1), shall obtain a statement signed by the foreign purchaser prior to export, acknowledging that the purchaser understands that such pesticide is not registered for use in the United States and cannot be sold in the United States. Section 17(a)(2) requires that a copy of the statement be transmitted to an appropriate official of the government of the importing country.[7]

Under this notification scheme, however, "there is generally no assurance the receiving official will forward the data to the user of the chemical," which may defeat the ultimate purpose of the labeling requirements.[8]

In the late 1970s, growing awareness of the health and environmental consequences of escalating pesticide use in the developing world placed governments in pesticide-producing countries in uncharted territory. Analyses of the "circle of poison" argued that the export of hazardous pesticides hurt us all. For the first time, governments were being held accountable (if only in humanitarian terms) for illness and environmental degradation half a world away.[12]

A 1979 report to Congress from the General Accounting Office (as of 2004, renamed the "Government Accountability Office") noted:

> Pesticides suspended, canceled, or never registered for use in the United States because of hazards associated with their use are exported routinely. Serious injuries have occurred from the use of these pesticides in other countries.[13]

The report's chapter on the need to monitor pesticide exports concluded:

> The uncontrolled export of hazardous pesticides poses dangers to U.S. citizens, as well as to people in other nations. The extent of danger, however, is not known, because the content, destination, and use of most exports are not monitored. Presently, federal law does not provide the means for tracking exports and minimizing hazards.[13]

Nearly thirty years later, this information gap has not been filled. No agency has a mandate to monitor exports in the manner that GAO felt would be essential to protecting public health in the U.S. and abroad. Moreover, current U.S. law still allows the export of pesticides not registered for use in this country (whether their registrations were never granted or have been taken away), as well as the import of banned pesticides for packaging or reformulation for export.[14]

International efforts to control trade in dangerous pesticides have included the Rotterdam Convention on Prior Informed Consent (PIC), and the Stockholm Convention on Persistent Organic Pollutants (POPs).[15] The Rotterdam Convention is designed to facilitate information exchange regarding the most hazardous chemicals, to ensure that importing countries have knowledge of potential risk before allowing imports. According to guidelines outlined in the Convention, chemicals are added to a "PIC list"—products for which the Convention Secretariat must produce and circulate documents that alert authorities in importing countries to their potential hazards and can inform decisions regarding their import.[16] The U.S. Congress has not approved legislation to enable full U.S. participation in either convention. If existing legislation is approved, exports of pesticides subject to these agreements will face restrictions. In the case of the PIC agreement, exports will not be allowed to countries that have stated they do not wish to import banned or severely restricted chemicals subject to information exchange requirements of the Rotterdam Convention; in the case of the POPs agreement, pesticides that have been determined to meet the definition of "persistent organic pollutant" as outlined in the treaty may not be exported.

However, these restrictions will not in themselves constitute complete export bans. Not all potential importers are parties to these treaties; in addition, the Stockholm Convention, while intended to bring about the elimination of POPs, allows parties to continue to use (and produce) specific POPs under special circumstances.[15]

TRACKING EXPORTS

In 1991, the Foundation for Advancements in Science and Education (FASE) began a project to gather and analyze available data regarding pesticide exports from U.S. ports, with particular attention to shipments of banned and highly hazardous pesticides to developing countries, where conditions of use and storage intensify the risks associated with pesticide use.

The project was intended to remedy a general scarcity of public record data regarding production, trade and use of pesticides. As noted in previous reports, no agency collects and publishes such data with sufficient detail to provide a clear picture of pesticide trade. The U.S. EPA has no mandate to collect comprehensive data on pesticide exports, and does not

TABLE 1 Total Exports, 2000–2003 (lbs)

2000	2001	2002	2003
761,357,764	736,038,719	433,776,914	528,390,004

have permission from the Department of Commerce to access the information in export declarations.[17]

However, commercial transcriptions of U.S. Customs shipping records are available for purchase, providing much greater detail than other public record sources.

FASE uses this data to compile reports on pesticide exports from the U.S. The figures cited in this paper are derived from analysis of shipping documents transcribed by the Port Import Export Retrieval Service (PIERS) of the Journal of Commerce. They do not account for shipments via truck or rail. The fact that a product is exported from a U.S. port does not necessarily mean that the product was manufactured in the U.S. It should also be noted that in many instances, the data provided in publicly-accessible records of individual shipments is incomplete, omitting vital information such as the specific name of the product being exported or the quantity exported in that shipment. In most cases, records do not state whether the product shipped is a technical grade product or a formulation.

FASE's first report, a review of three months of records for 1990, found that extremely toxic and U.S.-banned pesticides were being exported at a rate of nearly 60 tons per day. Due to the prevalence of undecipherable abbreviations, incomplete numeric shipping codes, generic terms (e.g., "pesticide," "weed killing compound," etc.) the specific compound shipped could be determined for only 25 percent of the shipments.[18]

A survey of 1991 exports found that this rate had increased to 80 tons per day.[19] A review of the three-year period between 1992 and 1994 found at least 25 million pounds of domestically banned pesticides had been exported[20]; and records for 1995 and 1996 showed exports of at least 21 million pounds of pesticide products forbidden to be used in the U.S.[21] During the years 1997–2000, exports of forbidden or severely restricted products had decreased to a rate of about 22 tons per day.[22]

For this report, we looked at U.S. Customs shipping records for the years 2001–2003, categorizing and enumerating pesticide exports from U.S. ports. The information contained in these records is not complete. It was only possible to identify the chemical being exported in 43 percent of all shipments (by volume). About a fourth of the remaining 57 percent were identified by pesticide type (e.g., "organochlorine pesticide," "organophosphate (OP) pesticide," etc.). Thus, many of the figures presented are likely to be conservative estimates. Nonetheless, they paint a more complete picture than is otherwise available given the tendency to protect details of trade as "confidential business information," out of the public record.

TABLE 2 Exports Attributed to Shipper "Monsanto"

Year	Total Exports	Shipper "Monsanto"
1993	486,138,116	0
1994	526,172,740	42,617
1995	630,040,438	40,927,501
1996	687,601,508	0
1997	785,885,594	112,745,632
1998	812,086,814	0
1999	831,308,281	0
2000	762,053,978	115,733,355
2001	739,839,645	266,661,329
2002	433,854,401	0
2003	528,594,668	80,815,176

2001–2003 FINDINGS

Total Volume

According to Customs records, nearly 1.7 billion pounds of pesticide products were exported between 2001 and 2003, a rate of more than 32 tons per hour.

The figure for 2002 was dramatically less than the 2001 total, representing a reduction of more than forty percent. In 2003, the total rose, but remained at the lowest level seen since 1994 (see Table 1).[20]

According to Croplife International, when the effects of inflation and currency exchange factors are taken into consideration, the global pesticide industry experienced market reductions in the years 1999–2003, with the greatest decline (6.8 percent) in 2001.[23]

The project database was examined from various perspectives in an effort to identify factors that could further explain the drop in exports between 2001 and 2002. One anomaly did emerge. Records from 2002 included no shipments from Monsanto. The previous year, the company was responsible for shipments totaling nearly 267 million pounds, a figure almost large enough to fully account for the 2002 decline. As noted in earlier reports from the project, companies may obtain permission from the Department of Treasury for their names to be withheld from transcriptions of Customs records. Monsanto may have withheld their name from Customs records in this way. There is no way to ascertain whether the Customs records for 2002 included exports from Monsanto or any other company. Aa review of the last 10 years of shipments explicitly attributed to Monsanto exemplifies the inexact, erratic public record that can result when no agency has a mandate to carefully and comprehensively monitor exports (see Table 2 for details).

Pesticides Forbidden in the U.S.

Between 2001 and 2003, nearly 28 million pounds of pesticides were exported whose use is forbidden in the United States. This is an average rate of 13 tons/day. The great majority of these exports can most accurately

TABLE 3 Exports of Pesticides Forbidden in the U.S., 2001–2003

	2001	2002	2003
Banned	60,026	22,393	87,195
Unregistered	13,442,584	5,893,240	4,336,991
Cancelled	157,260	65,176	36,568
Discontinued	1,812,327	452,998	1,457,573
Total	15,472,197	6,433,807	5,918,327

TABLE 4 Exports of Severely Restricted Pesticides

	2001	2002	2003
carbofuran	4,679,095	2,113,174	1,754,213
methamidophos	332	18,394	0
tributyltin	160,510	58,839	0
lindane	0	45,185	0

TABLE 5 WHO Class 1a Exports[27]

	2001	2002	2003
aldicarb	3,665,153	5,193,378	4,124,414
brodifacoum	—	27,286	45,586
captafol	14,251	—	—
difethialone	—	81,360	19,459
diphacinone	—	26,731	—
disulfoton	288,054	72,564	118,573
methyl parathion	187,062	110,181	—
phorate	208,108	427,126	297,639
sodium fluoroacetate	—	1,780	7,124
terbufos	1,221,556	568,045	91,225

be characterized as "unregistered": they are produced for export only and have never been registered with the U.S. EPA. The rate of export of these products decreased each year during this period, with 2003 exports representing less than 40% of the total for 2001. The 58% reduction between 2001 and 2002 is even greater than the 43% reduction in total exports.

During 2001–2003, the average rate of export of banned pesticides was 28 tons/year, as compared to the average rate of more than 50 tons/month between 1997 and 2000.[22] Banned products included captafol, dinoseb, and mercury-based pesticides. In addition, more than 6 million pounds of pesticides were exported that were described in Customs records as "arsenical pesticide" through generic terms or UN codes. It is possible that some percentage of these exports were copper arsenate or arsenic trioxide, both of which are banned.[24]

In addition, nearly 9 million pounds of severely restricted pesticides were exported, an average rate of more than 28 tons/week.

Restricted Use Pesticides

As defined by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), a "restricted use pesticide" (RUP) is one that:

> . . . when applied in accordance with its directions for use, warnings and cautions and for the uses for which it is registered, or for one or more of such uses, or in accordance with a widespread and commonly recognized practice, may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator.[7]

Accordingly, in the U.S. it is illegal for a restricted use pesticide to be applied by anyone other than a certified pesticide applicator or a person under the direct supervision of a certified applicator.[7] This protective standard, however, is not enforceable when products are exported.

More than 127 million pounds of RUPs were exported between 2001 and 2003.[36] This is an average rate of 58 tons per day.

With exports totaling more than 17 million pounds, or nearly 8 tons/day, the organophosphate compound chlorpyrifos was the highest volume RUP. More than 85% of these shipments were to developing countries, with Brazil (3.7 million pounds), Argentina (2.6 million pounds), China (2 million pounds) and Colombia (1.6 million pounds) the largest importers.

Recent U.S. regulatory action on chlorpyrifos use exemplifies the uneven nature of international pesticide guidelines. In April 2000, a group of distinguished pediatricians, toxicologists and epidemiologists wrote to the EPA administrator, expressing concern about the neurotoxic effects of the chemical and the particular (and relatively unexamined) vulnerability of children.[37] Beginning in 2000, the U.S. EPA began to phase out the use of chlorpyrifos in situations where children were likely to be exposed.[38] (A study published after the EPA decision also found that exposure during pregnancy may result in lower birth weight.[39]) As discussed above, however, it can be assumed that in the developing world women and children will be directly involved in the application of this pesticide, facing risk factors much greater than those that triggered public health concerns—and regulatory action—in the U.S.

Highly Toxic Pesticides: Unsafe for Use

Among the recommendations of the Fourth Intergovernmental Forum on Chemical on Chemical Safety was that governments should consider restricting or prohibiting the use of chemicals classified 1a ("extremely hazardous") or 1b ("highly hazardous") by the World Health Organization.[25]

This recommendation reflects numerous realities of pesticide use in the developing world, including lack of protective equipment, leaking backpack sprayers, long days working in conditions of continual exposure, and lack of washing facilities for cleanup after working.[26]

More than 36 million pounds of WHO 1a and 1b pesticides were exported between 2001 and 2003, at an

average rate of more than 16 tons/day; "extremely hazardous" products accounted for nearly 47% of the total. The yearly total declined each year during the three years studied.

In the classification system outlined in the U.S. Code of Federal Regulations, the most acutely toxic pesticides—those with an oral LD_{50} up to and including 50 mg/kg, the threshold for WHO 1b classification—are designated "Class I."[28] Nearly 81 million pounds of Class I pesticides were exported between 2001 and 2003, an average rate of 37 tons/day. Sixty-seven percent of these shipments were to developing countries; an additional 13% were sent to Belgium and the Netherlands, suggesting that at least some were then shipped to other destinations.

According to the EPA, adequate personal protective equipment for workers using Class I pesticides includes: coveralls worn over long-sleeved shirt and long pants; socks; chemical-resistant footwear; chemical-resistant gloves; respiratory protection device; and protective eyewear.[29] As noted, such protection is rarely available in the developing world, and is generally inappropriate for southern climates.[30] Moreover, in farming families in the developing world, mixing, loading and spraying pesticides may be the responsibility of women and teenage children,[31] populations at higher risk for adverse effects from their exposures.

Developing countries with the highest rate of import of Class I pesticides included Brazil (11.5 million pounds), Costa Rica (6.5 million pounds), China (3 million pounds) and Guatemala (2.9 million pounds).

It is not possible to delineate connections between these exports and specific incidents of pesticide-caused illness or to state with certainty what costs might be associated with such illness, whether related to treatment or reduced productivity. However, it is interesting to note that the annual economic costs associated with pesticide poisoning in the United States, whose 300,000 annual poisonings represent about one percent of the worldwide estimate of 26 million,[5] have been estimated to be more than $1.2 billion.[32]

Pesticides Subject to International Agreements

The U.S. has signed, but not yet ratified, the Rotterdam Convention on Prior Informed Consent (PIC) and the Stockholm Convention on Persistent Organic Pollutants (POPs). Between 2001 and 2003, 440,446 pounds of pesticides were exported that were included on the PIC list, an average rate of 1.4 tons/week. This figure is less than half the total of 1.3 million pounds of these products exported in the previous three years. A single shipment in 2001 (43,960 pounds) was noted that may also be a PIC pesticide. This commodity was described as "Veslicol" [*sic*]; "Velsicol 1068" is a trade name for chlordane, while "Velsicol 104" is a trade name for heptachlor.

TABLE 6 Importing Countries, Class I Pesticides (2001–2003; > 1,000,000 lbs)

Brazil	11,536,056
Costa Rica	6,475,622
China	3,094,001
Korean Republic	3,070,988
Guatemala	2,863,419
Taiwan	2,325,035
Dominican Republic	2,240,100
Colombia	2,155,527
India	1,971,862
Indonesia	1,673,595
Ecuador	1,550,150
Thailand	1,106,571

TABLE 7 High Export Volume RUPs, 2001–2003

Pesticide	Pounds
acetochlor	14,838,444
alachlor	5,962,651
aldicarb	12,982,945
atrazine	11,822,721
chlorothalonil	16,452,056
chlorpyrifos	17,259,255
chromated copper arsenate	2,732,665
diazinon	3,869,164
ethoprop	5,616,774
methomyl	4,538,995
methyl bromide	4,016,071
paraquat	2,961,228
picloram	3,125,552
simazine	4,203,965
terbufos	1,880,826
triclopyr	2,828,513

According to Customs records, the 2003 shipments of dinoseb included more than 20 tons bound for China. In 1993, China notified the PIC Secretariat (under then-voluntary procedures) that it did not consent to the import of dinoseb.[33] A small quantity (662 pounds) of mercury-based pesticides were shipped to Guatemala in 2003, which had also made a "no consent" notification in 1993.

In February 2006, the Chemical Review Committee for the Rotterdam Convention determined that endosulfan meets the criteria for inclusion in the PIC procedure and recommended that parties to the convention add it to the list at their next meeting.[34] Just over 300,000 pounds of endosulfan were exported between 2001 and 2003, with the great majority (93%) shipped to Central and South America.

As compared to the Rotterdam Convention's goal of improving information exchange, the intent of the Stockholm Convention is to bring about the elimination of chemicals identified as Persistent Organic Pollutants (POPs). Most pesticides on the POPs list are also included in the PIC procedure, though none of the PIC products exported during this period are also on the POPs list. However, five pesticides exported during the period studied (chlordecone, dicofol, endo-

U.S. Export of Pesticides Included on the Stockholm Conventions' "PIC List"

	2001	2002	2003
captafol	14,251	—	—
dinoseb	—	—	86,415
mercury-based pesticide	1,026	22,393	662
methamidophos	332	18,394	—
methyl parathion	187,062	110,181	—
pentachlorophenol	—	630	13,463
Total	202,671	150,968	87,077

sulfan, methoxychlor and pentachlorophenol) have been identified by the World Wildlife Fund as candidate POPs. In all a total of more than 200 tons of these pesticides were exporting during 2001–2003.[35]

Products Associated with Cancer

Between 2001 and 2003, more than half a billion pounds of pesticides known or suspected to cause cancer[40–42] were exported from U.S. ports, an average rate of nearly 11 tons/hour. More than half of these shipments (57%) were to developing countries.

California's Proposition 65 list is a useful tool for identifying chemicals that cause cancer or reproductive hazards. Proposition 65, is an initiative approved by California voters, that requires public notification of the presence of any of a published list of chemicals known to the state to cause cancer, birth defects or other reproductive harm. A chemical to be added to the Proposition 65 list for several reasons:[43]

- A determination by either of two independent committees of scientists and health professionals that the chemical has been clearly shown to cause cancer or birth defects or other reproductive harm. Members of these committees (the Carcinogen Identification Committee [CIC] and the Developmental and Reproductive Toxicant [DART] Identification Committee) are appointed by the Governor and are part of the Science Advisory Board of the state's Office of Environmental Health Hazard Assessment.
- If an "authoritative body" designated by CIC or DART has identified it as causing cancer or birth defects or other reproductive harm. Such groups include the U.S. Environmental Protection Agency, U.S. Food and Drug Administration (U.S. FDA), National Institute for Occupational Safety and Health, National Toxicology Program and the International Agency for Research on Cancer.
- If an agency of the state or federal government requires that it be labeled or identified as causing cancer or birth defects or other reproductive harm.
- If the chemical meets scientific criteria identified in the California Labor Code as causing cancer or birth defects or other reproductive harm.

Nearly 72 million pounds of pesticides from the Proposition 65 list were exported from the U.S. between 2001 and 2003, a rate of nearly 230 tons per week.[44] The highest volume products were chlorothalonil (16.4 million pounds), alachlor (6 million pounds), captan (6 million pounds), ethoprop (5.6 million pounds) and mancozeb (5 million pounds).

Pesticides classified as "probable" or "likely" carcinogens by the U.S. EPA were exported at a rate of 1.5 tons/hour between 2001 and 2003, a total of more than 81 million pounds.[45]

The millions of children working in agriculture face heightened risk from exposure to these products. A case control study found risk of childhood acute lymphoblastic leukemia was associated with indoor and garden exposure to pesticides, in particular prenatally.[46] A review of case reports and case control studies of cancers linked to pesticide exposure concluded that "children may be particularly sensitive to the carcinogenic effects of pesticides."[47] The researchers suggested

TABLE 8 U.S. Export of Pesticides Associated with Cancer, by Importing Country (2001-2003; > 1,000,000 lbs)

Argentina	88,822,997	India	3,733,345
Australia	69,282,394	Indonesia	22,884,612
Bahamas	1,615,248	Japan	6,855,414
Belgium	78,557,655	Korean Republic	7,268,141
Brazil	43,460,964	Malaysia	51,586,926
Costa Rica	9,263,288	Mexico	2,331,517
Canada	79,938,041	New Zealand	999,090
Chile	2,803,323	Netherlands	2,813,198
China P	3,931,254	Puerto Rico	5,890,533
China T	7,103,417	Panama	1,784,004
Colombia	8,671,725	Philippine Republic	3,193,846
Dominican Republic	2,852,725	Republic of South Africa	12,887,851
Ecuador	2,787,342	Thailand	4,585,097
France	3,516,737	United Kingdom	2,589,077
Germany	1,393,998	Uruguay	1,087,281
Guatemala	6,781,402	Venezuela	1,240,787
Honduras	4,571,272		

TABLE 9 U.S. Export of Pesticides Associated with Endocrine Disruption, by Importing Country (2001-2003; > 1,000,000 lbs)

Argentina	14,442,530	France	6,489,812
Australia	14,546,973	Guatemala	1,557,779
Belgium	33,242,629	India	1,922,222
Bangladesh	1,259,359	Indonesia	1,758,427
Brazil	19,485,633	Japan	2,997,132
Costa Rica	1,494,205	Korean Republic	5,134,718
Canada	79,938,041	New Zealand	2,942,622
Chile	1,612,822	Netherlands	5,024,962
China	6,696,065	Puerto Rico	2,126,299
Taiwan	3,625,035	Republic of South Africa	5,104,943
Colombia	6,931,637	Singapore	1,845,911
Ecuador	1,179,366	Thailand	4,828,051

that, given this increased susceptibility and vulnerability, it would be best, if possible, to eliminate childhood pesticide exposure.

For most U.S. children, this is potentially achievable by eliminating household insecticides and lawn and garden chemicals. For the millions of children working in agriculture in the developing world, elimination is not an option—occupational exposures are compounded by such realities as storage of pesticides in living spaces, continuous wearing of contaminated clothing, and agricultural runoff into drinking water sources.

Additionally, there are known genotoxic effects, frequently measured as chromosomal aberrations, associated with high pesticide exposures due to intensive use, misuse or failure of control measures[48], which could lead to sperm abnormalities, spontaneous abortion, birth defects, or cancer risk.

Endocrine Disruptors

Even extremely low levels of exposure to some pesticides, such as atrazine, methoxychlor, and vinclozolin, may indirectly cause adverse health effects by interfering with the endocrine system and altering hormonal function.[49] The potential health consequences can be far-ranging, including altered sexual development, reproductive cancers, and impairments in thyroid function.[50] Although much of the concern arises from animal and wildlife research, a recent study in organophosphate-exposed agricultural workers in Mexico showed elevated follicle stimulating hormone levels during the spraying season.[51]

A recent animal study has raised the possibility that adverse effects of endocrine disrupting pesticides could be passed not only to the child of an exposed mother, but to all succeeding generations.[52] This possibility adds to existing concerns about fetal exposure to endocrine disruptors, and the very low exposures—parts per billion or even parts per trillion—that have the potential to affect development.

Nearly 240 million pounds (238,384,020) of pesticides considered potential endocrine disruptors were exported during the three years studied, an average rate of more than 100 tons/day. Thirty eight percent of these shipments were to developing countries. An additional 16% went to ports in Belgium and the Netherlands, most likely en route to other destinations.

Pollinator Toxins

The annual value of the ecosystem services provided by pollinators has been estimated at $200 billion.[53] In the U.S., agricultural losses associated with pesticide-caused reduction in pollination may be as much as $4 billion each year.[32] Beyond the impact on agriculture, the decline of bees and other pollinators in diverse ecosystems may contribute to the loss of plant species, as large numbers of plants compete for scarce pollination activities.[54]

Between 2001 and 2003, more than 125 million pounds of pesticides were exported that have been identified as "highly toxic" to bees.[55] This is a yearly average of 42 million pounds, or two tons/hour; double the average rate of 21 million pounds/year seen between 1993 and 2000. The nearly 300% increase between 2001 and 2002 contrasts sharply with the more than 40% overall decrease in exports. Exports of dimethoate (81 million pounds) accounted for nearly 65% of the 2001–2003 total.

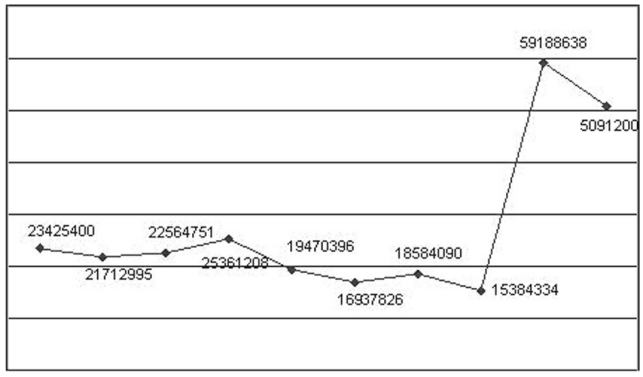

Figure 1—Exports of pesticides "highly toxic" to bees,[55] 1993–2003.

TABLE 10 U.S. Exports of Pesticides of High Avian Toxicity (High volume exports)

	2001	2002	2003
carbofuran	4,679,095	2,113,174	1,754,213
chlorfenapyr	829,571	201,282	139,203
diazinon	1,002,653	875,746	1,990,765
disulfoton	288,054	72,564	118,573
oxamyl	806,362	1,128,497	1,342,153
phorate	208,108	427,126	297,639
terbufos	1,221,556	568,045	91,225

Many species of birds are also important pollinators. It has been estimated that by 2100, as many as 14% of all bird species will be extinct, with those that provide pollination functions at greater than average risk.[56] A variety of factors, from loss of habitat to the introduction of non-indigenous species can contribute to these losses, but there is no doubt that the release of pesticides with high avian toxicity is an additional and undesirable stressor. Determining whether a specific pesticide is responsible for decrease in a specific species is made difficult by the fact that although there are an estimated 10,000 species of birds, pesticides are usually tested against no more than 1–3 species.[57]

To estimate the impact of pesticides on a broader range of species, some have advocated the concept of an "HD_5"—a dose that would be hazardous for 5 percent of species.[57] By this standard, pesticides that would be anticipated to be the most hazardous to birds—those with an HD_5 of less than 1 mg per kg of body weight—were exported at a rate of 9.5 tons per day, a total of nearly 21 million pounds over the three-year period.

It is an illuminating exercise to consider the potential number of lethal doses that shipments of this size might represent if the products were used as avicides. For example, one of the products in the highly hazardous group, oxamyl, has an avian LD_{50} of 30 mg/kg of body weight.[58] About 3.3 million pounds were exported during the three-year period. Nearly 800,000 pounds went to Central and South American countries, which are breeding grounds for 300 species of hummingbirds, which play a crucial role in pollination.

Assuming an average weight of 3 g per bird, and a fifty percent kill rate, enough oxamyl was exported to these regions to provide a fatal dose to 2 trillion hummingbirds. While this is an abstract calculation that makes no attempt to take into account the wide range of variables involved in the actual use of the pesticide, it offers a perspective on the introduction of such compounds into an ecosystem.

DISCUSSION

The rate of export of banned pesticides, and products included in the PIC and POPs regimens, has decreased dramatically over the last decade. This seems to indicate that the attention brought to the "circle of poison" in the late 1970s and early 1980s has resulted in a change of practice. However, this does not mean that workers (or the environment) in the developing world no longer face unreasonable risk. As discussed above, conditions of use continue to exacerbate the hazards of agricultural chemicals. With three million annual pesticide poisonings, both occupational and deliberate, and over 200,000 deaths, many in children, the problem remains urgent.[59,60]

Though exports of banned chemicals have decreased, rates of export of highly toxic pesticides, carcinogenic pesticides and neurotoxic and endocrine disrupting pesticides remain high.

Equally troubling is the fact that in recent decades, researchers have raised questions about previously unanticipated (and unexplored) risk factors associated with pesticide products. For example, some researchers have suggested that suicides due to organophosphate (OP) poisoning, may constitute *an effect* of OP exposure-related depression in farm communities. Pesticides may have chronic neurotoxic effects, as indicated by the comment from a review on the subject by Kamel in 2004: "It is possible that the most sensitive manifestation of pesticide neurotoxicity is a general malaise lacking in specificity and related to mild cognitive dysfunction."[61] Likewise, serious concerns have been raised regarding pesticides' neurodevelopmental effects, the possibility of chemical injury being passed to successive generations, variations in response when children are exposed, and other serious health issues. Additionally so-called 'inert ingredients' in pesticide formulations go undisclosed and are not monitored for actual biological activities and potential toxicities.[62]

Decades can pass between the first publication of such findings and the development of appropriate safety or regulatory standards. Moreover, it has become apparent that existing regulatory paradigms, and the methods for assessing risk on which they depend, are likely to be unsuitable for determining the appropriate public health response to potential hazards such as endocrine disruption.[62]

Regulatory failures or omissions can have lingering consequences. The nematocide DBCP was banned in the U.S. in the late 1970s due to concerns about reproductive effects, including sterility, but exports continued. DBCP–related injuries have "spawned at least 470 lawsuits with at upwards of 20,000 plaintiffs in total."[63] In 2007, a Los Angeles jury awarded $3.2 million to six Nicaraguan farmworkers who had sued Dole Food Co., Inc., arguing that application of DBCP on the plantations where they worked three decades ago had caused them to become sterile.[64]

Lawsuits related to such incidents turn on the interpretation of a once-obscure Act called the Alien Tort Claims Act ("ATCA"),[65] which allows foreigners access to U.S. courts. The ATCA was enacted in 1789,[66] and

did not gain traction and human rights currency until it was raised in the landmark case of *Filartiga v. Pena–Irala* in 1980.[67] The Act provides that the "district courts shall have original jurisdiction of any civil action by an alien for a tort only, committed in violation of the law of nations or a treaty of the United States."[67] The fact that both the PIC and POPs treaties have entered into force could have a significant impact in regard to what the "law of nations" might encompass as far as pesticides are concerned.

Industry has attempted to reduce the need for chemical inputs through genetic engineering (GE) techniques. However, while large-scale implementation of GE crops initially reduced herbicide use, changes in weed communities and resistance have made it necessary to apply additional herbicides and or/increase rates of application, resulting in an increase in the overall volume of pesticides applied in the production of soybeans, corn and cotton.[68]

Insect resistance is also an ongoing problem. As the late entomologist Robert Van Den Bosch noted, insects are the most successful animals to appear in the last 300 million years—they comprise over one million species, occupy niches from soil to furniture and clothing, and can quickly adapt to environmental adversity or opportunity, including simply flying away from pesticides.[69] Over more than half a century, U.S. insecticide use has increased 20-fold, while the percentage of pre-harvest crops lost to insects has nearly doubled, from seven to thirteen percent.[70]

For the most part, the costs associated with health and environmental effects resulting from pesticide use are borne by society. It is possible that in the U.S. alone, these costs—which include such things as domestic animal deaths, groundwater contamination, regulation, bird and fishery losses, and public health expenditures—could be as much as $24 billion each year. There is no reason to assume that the scale of this damage is less in the developing world.

Beyond Regulation: Implementing a New Paradigm

It is beyond the scope of any regulatory scheme to address all possible risks associated with international pesticide trade. Moreover, it has been suggested that any attempt to reduce environmental degradation by stricter regulation, in order to be "less bad," may be misguided.

> In a world where designs are unintelligent and destructive, regulations can reduce immediate deleterious effects. But ultimately regulation is a signal of design failure. In fact, it is what we call a license to harm: a permit issued by a government to an industry that it may dispense sickness, destruction, and death at an 'acceptable' rate.[71]

It would be hard to imagine a sector where this concept is more relevant than it is to the pesticide industry. While it is useful for policy makers and public interest groups to work to reduce the liabilities of chemical-intensive agriculture, the best long-term strategy would be a determined effort to implement a new paradigm. At present, agricultural chemicals are considered "good" or "bad" according to the extent to which they damage health or the environment. What if agricultural technologies were assessed according to how well they utilized, sustained, or even enhanced the "capital" of the natural world—soil, water, life forms, etc.?

A group of fundamental assumptions for "natural capitalism" includes the following principle:

> The environment is not a minor factor of production but rather is "an envelope containing, provisioning, and sustaining the entire economy."[70,72]

Implementation of this concept can have powerful results. A recent review of 286 interventions involving 3% of the cultivated area in the developing world found that an average 79 % increase in productivity was achieved by improving environmental services. A 71% decrease in pesticide use was associated with a 42% increase in yields.[73]

Even the American Chemistry Society has issued a position statement that has the potential to be consistent with a focus on preserving ecosystems, expressing the belief that "the principles of pollution prevention, environmental sustainability, and green chemistry will complement traditional regulatory strategies to minimize and avoid future pollution."[74]

In practice, however, the long-range commitment, discipline and self-sacrifice that environmental protection can require are often at odds with the short-range cycles of politics and business. This is compounded by the fact that technical staff in regulatory agencies may have their work interpreted (if not ignored) by the political appointees who supervise them.[75]

A substantial shift away from an operating basis focused on "less bad" outcomes will require a number of far- and deep-reaching changes. It should be noted that these recommendations have been included in previous reports from this project; despite changes in the pattern of exports, the fundamental changes that are likely to lead to improvement remain the same:

Aggressive efforts should be made to implement alternatives to chemical-intensive agriculture. A recent report from the World Resources Institute raises serious questions about the likelihood that ecosystem-damaging practices such as pesticide-intensive agriculture offer a long-range means to feed the world.[76] In cases where pesticide use cannot be eliminated altogether, Integrated Pest Management (IPM) strategies can dramatically reduce pesticide use. While biotechnology is sometimes characterized as "IPM," field-based programs have pointed to more cost-effective solutions that could be broadly implemented in developing countries.[77]

Exporting countries should assume proactive, precautionary stance in regard to pesticides. A suspect chemical can remain in use for decades before it is banned. Decades can also pass before epidemiological studies confirm the poisonings that can be predicted when highly toxic pesticides are used in developing countries, if such studies are undertaken at all. Whatever the limits of law might be, ethical responsibility for hazardous exports cannot end at our borders.

There is no justification for any "double standard" in regard to protecting health and the environment. If EPA does not have certainty that a product poses no unreasonable risk, it should not be exported. Part of the rationale for not registering export-only products is that the conditions of use cannot be duplicated in this country. It is not likely that sale would commence without testing, however—and it is hard to accept that no scientist in this country could interpret the results. Export of banned pesticides should be prohibited, as should exports of pesticides that EPA has never registered. Congress must ensure that EPA has the resources to fully evaluate the hazards posed by pesticides leaving the U.S., and the authority to act on its findings.

The quality and quantity of information regarding pesticide production, trade and use must be improved. Accurate information will be necessary to monitor compliance with the PIC and POPs agreements. In the absence of complete information about trade and production, government officials, public interest groups, researchers and others cannot identify the principal targets for risk reduction or regulation.

A system for electronic filing of export declarations (the Automated Export System or AES) already exists in the U.S. AES requirements for pesticide shipments should include a precise description of the chemical involved, its registration status, and any international agreements to which it is subject. The EPA should have full access to this data, and it should be in the public record.

Hazardous pesticides should be phased out when safer alternatives exist. A "substitution principle" enacted in Swedish legislation forbids the use of chemical products for which less-hazardous substitutes are available. Under such a scheme, if a new pesticide is registered that is safer than an older one, the older one automatically loses its registration. Implementing such a system in the U.S. would have far-ranging effects on exports, particularly if the export of unregistered products were prohibited.

Recent developments in the field of energy—the spiraling costs of fossil fuel, conflicts in oil-producing countries, and signs that global warming may arrive sooner than anticipated—have highlighted the shortcomings of policy and the failure to implement available beneficial technologies. However, in the face of a variety of destructive—even disastrous—possibilities, government, business leaders and scientists have begun to show something of a united front. The same urgency should be brought to reforming the practice of agriculture. What could be more hazardous than to continuously erode the diversity, abundance and fertility of the planet on which we depend? The practice of postponing future-oriented programs until the present has become intolerable should be targeted as the most fundamental "non-sustainable" policy.

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