From: Bob VADAS
To: Jennings, Jonathan (ECY);
Subject: FW: Public comment period extended for proposed Aquatic Mosquito Control NPDES General Permit
Date: Monday, March 01, 2010 2:46:16 PM
Attachments: Vadas-Gagne97.pdf

Dear Jonathan;

Although I've not read the whole permit, I do have a chemistry minor (including courses in organic chemistry) and past experience with pesticide impacts (see the attached report, which is relevant to both temperate and tropical ecosystems):

Vadas, R.L. Jr., and R. Gagné. 1997. The impacts of tropical pesticides on terrestrial
and aquatic ecosystems and human health: a literature review and action plan. Prepared for the Calgary Rainforest Action Group. Calgary, AB, Canada. 16 pp.

WDOE's public-information statement for the updated insecticide ("adulticide") spraying of mosquitoes (see http://www.ecy.wa.gov/biblio/1010006.html) says that the following are the new (2010) recommendations:

"Natural pyrethrins, pyrethroids, permethrin, resmethrin, sumithrin (d-phenothrin), piperonyl butoxide, and naled. Naled is an organophosphate pesticide for emergency use only."

As discussed in my report, the four main synthetic compounds include organochlorines (now banned because of their long half-lives), organophosphates, carbamates, and pyrethroids. Although the latter three insecticides have shorter half lives than organochlorines, they work because of their higher, albeit shorter toxicity, such that acute effects on humans and aquatic ecosystems are highly likely. Indeed, when I worked a decade ago as an aquatic ecologist in the Greater San Francisco Bay Area, CA, a proposed mosquito-spraying project with non-organochlorine insecticides was stopped by concerned scientists (like myself) and citizens, because acute exposures were a big concern. Indeed, EXTENSIVE sign postings would've been needed to keep people away from the proposed spraying areas when insecticide toxicity was dangerous, not to mention aquatic-ecosystem damage. Hence, other management techniques like biocontrol should be considered for mosquito control, rather than pyrethroids and organophosphates like naled; the latter shouldn't be considered even for emergency use because these compounds have chemical similarity to nerve gases. Pyrethroids are more environmentally mobile than organochlorines and are known to impact fish foods.

Sincerely,

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Subject: FW: Public comment period extended for proposed Aquatic Mosquito Control NPDES General Permit
Date: Mon, 1 Mar 2010 13:40:45 -0800
From: Robert.Vadas@dfw.wa.gov
To: bobesan@q.com

From: News and Information about water quality from the Department of Ecology [mailto:ECOLOGY-WATER-QUALITY-INFO@LISTSERV.WA.GOV] **On Behalf Of** Howard, Sandy (ECY)
Sent: Friday, February 26, 2010 4:17 PM
To: ECOLOGY-WATER-QUALITY-INFO@LISTSERV.WA.GOV
Subject: Public comment period extended for proposed Aquatic Mosquito Control NPDES General Permit

To parties interested in mosquito control,
Ecology is extending the public comment period by one week on the new, proposed Aquatic Mosquito Control NPDES General Permit. This will allow more time for interests to provide comments after the public hearing on March 9, 2010. The deadline for written comments is 5 p.m., March 17, 2010. We have also posted this update on Ecology's Mosquito Permit website at www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/mosquito/mosquito_index.html.

If you have questions, contact:
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Aquatic Pesiticides and CAFOs
Water Quality Program
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"Rather than stop the poisons at the source, those who have violated the environment have... put the poisonous wastelands nearest the black, brown, and the poor - the line of least resistance... But because we live in one big room called Planet Earth, what may be the backyard of a family farmer or black, brown, or poor person today, affects everybody as soon as the winds blow or the waters flow."

- Jesse Jackson

"Never forget that your politicians are not your leaders ... You are their leaders, and they are your representatives."

- Helen Caldicott,
Former President, Physicians for Social Responsibility

CRAG WISHES TO THANK

Barbara Burrgraff of the Alberta Ecotrust Foundation and her husband Brian Freeston for the donation of their 386 computer, without which this project could never have been done.

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Calgary Rainforest Action Group

THE IMPACTS OF

TROPICAL PESTICIDES ON TERRESTRIAL AND AQUATIC ECOSYSTEMS AND HUMAN HEALTH: A LITERATURE REVIEW AND ACTION PLAN

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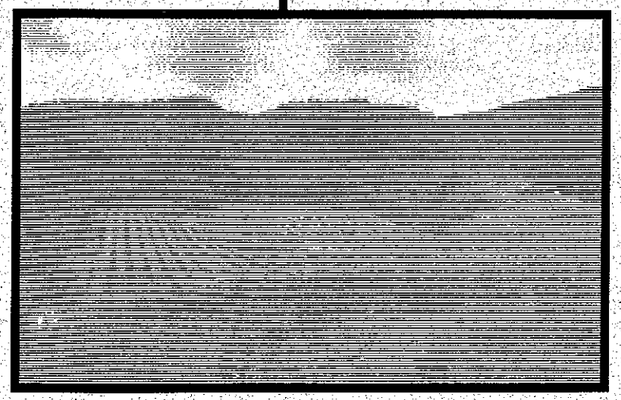

Prepared for:
Calgary Rainforest Action Group
Date: July 18, 1997

16 pp.

Bob Vadas, Jr.

"Everything is connected to everything else."
- Barry Commoner's *First Law of Ecology*

EXECUTIVE SUMMARY

The present report is the full, technical text, for more scientifically inclined people and those citizens who otherwise want detailed information. A shorter version of the report is also available, intended for the use by the general, layperson public (Vadas and Gagne 1997).

The focus of the report is on pesticide impacts and management in tropical environments. The information includes (a) the types of pesticides and their toxicity; (b) pesticide impacts on tropical ecosystems, including soil, groundwater, and riverine resources and human and other biological organisms; (c) the types of crops that are subjected to heavy pesticide use and are imported to North America; and (d) a management (action) plan for citizens and consumers. Special attention was given to DDT and monocrotophos pesticides that have caused problems in Latin America, e.g., for Swainson's hawks in Argentina.

The report begins with an overview of the alarming negative impacts of pesticides on tropical ecosystems, including humans. We also discuss the several ironies that call into question the benefits of pesticides relative to their costs for agricultural and medical uses. The history of pesticide development, including the types of pesticides and their toxicity, are then reviewed; particularly dangerous pesticides include fumigants (that are inhaled by pests) and synthetic, organic insecticides (e.g., organochlorines and organophosphates), although certain chemicals of other pesticide types have been known to cause fish and/or wildlife kills. Terrestrial wildlife particularly sensitive to pesticides include bees and birds, especially raptors (e.g., Swainson's hawk) and songbirds (e.g., dickcissel) that migrate between tropical and temperate environments and gather in large aggregations in tropical farmlands. Kills of tropical fishes and amphibians have also resulted from pesticide poisoning of waters, and even fishes in northern Canadian lakes have been contaminated by tropical pesticides that were transported over long distances by air currents. These results highlight the global nature of pesticide problems.

Review of the impacts of pesticides on human health reveals the extensive poisoning and death of farm workers in tropical and other lesser-developed countries (LDCs), often because of inadequate safety precautions and use of dangerous pesticides that are avoided in industrialized-temperate ('developed') countries. Special attention is given to pesticide-related poisoning of chemical-plant workers in Bhopal, India, and U.S. military veterans in Vietnam. Organochlorine, organophosphate, and some carbamate insecticides (used to kill insect and vertebrate pests) are particularly dangerous to humans, via impacts on the nervous and other organ systems of the human body; some of the more severe potential effects appear to be genetic damage, cancer, and birth defects. Clearly, alternatives to heavy pesticide (and fertilizer) usage need to be implemented, e.g., more ecologically oriented techniques such as biological control and landscape design. Consumers in developed countries can help reduce global pesticide usage and poisonings and destruction of tropical rainforests by buying organically grown grocery products (e.g., fruits, vegetables, cereals, and clothes) and by putting pressure on their governments to (a) promote social justice in tropical and other LDCs, (b) implement legislation to prevent export of dangerous pesticides to other countries, (c) provide economic incentives for LDCs to use safer pesticides and non-chemical means of pest control, and (d) promote monitoring, safety, and contingency (emergency) action programs in LDCs for pesticides.

The following report follows in the tradition of Rachel Carson and Theo Colborn in reviewing literature relevant to the negative impacts of pesticides, syntheses that are often not encouraged in academia (which is overly concerned with new research) and often incur the wrath of the less-than-objective chemical industry (Marco et al. 1987; Colborn et al. 1997; Helvarg 1997). The senior author (RLV) has researched the report as an independent contractor, focusing especially on pesticide impacts and management in tropical environments. Unfortunately, we have had to rely largely on U.S. data, given that lists of pesticides that are banned or unregistered (despite manufacture) in Canada are unavailable from Canada's Pesticide Management Regulatory Agency.

INTRODUCTION

Pesticide use in temperate and tropical ecosystems has often (a) improved the yield and appearance of agricultural crops and (b) controlled disease-carrying insects (e.g., malaria-infected mosquitoes), but often at great expense to soil, fish, and wildlife resources; groundwater and drinking water; and human health (Marco et al. 1987; Lee 1991; Dinham 1993; Jukofsky and Willie 1993; Miller 1994). Given that these toxins are used to control biota that humans consider to be pests, as well as various non-target species, these chemicals are perhaps better called 'biocides' (Miller 1994). Indeed, pesticide poisoning,

cancer, and deaths are common for humans, domestic animals, and wildlife in temperate and especially tropical countries (Steinman 1990; Anon. 1997a). Particularly frightening is the high potential for pesticides and other toxins to show synergistic effects, i.e., contaminants together may cause worse impacts than the combined individual effects of these chemicals (Cope 1971); the U.S. Environmental Protection Agency (EPA) is only now recognizing and incorporating this information into its testing procedures (Anon 1997c; Rodale 1997). Another recent, alarming finding is that pesticides can act as hormone impostors to interfere with reproductive behavior, physiology, and success of fish, wildlife, and humans in heavily polluted U.S. watersheds (Colborn et al. 1997; Johnson 1997), including potential increases in human breast cancer from estrogen mimics (Koppell and Sevinsky 1994). Often, the breakdown products or secondary ingredients of pesticides are worse than the active ingredients themselves, even though they are not usually tested or advertised on product labels as well as active ingredients, such that the danger of pesticides is further underestimated (O'Brien 1990a; Miller 1994; Johnson 1997).

With year-round sunshine and rock-bottom wages, growing export crops in lesser-developed countries (LDCs) is good business. There is, however, the hurdle of producing a single product of uniform size, color, and appearance. Complicate this further with monocrop plantations spanning the horizon, i.e., pest heaven, and it becomes a steep uphill battle against nature. The miracle is achieved by the liberal use of chemical fertilizers (which cause their own problems via eutrophication of water bodies [Reuss et al. 1970]) and pesticides. In fact, perhaps as much as 20% of tropical pesticides are used solely to improve appearance (Rauber 1997). Without the "cumbersome" environmental-protection laws of industrialized-temperate ('developed') countries, the chemicals used are typically powerful poisons which have either been banned in North America or have never been registered here (Thomas 1994). But we still manufacture them for export, although such unwanted toxic exposure is akin to assault and battery (O'Brien 1990a). Unfortunately, such intense agriculture is a prime mechanism behind the loss of tropical rainforests and wildlife; e.g., Central America has lost 2/3 of its primary rainforest to make way for plantations and cattle pasture (Thomas 1994).

Increased pesticide use has led to several ironies that call into question the benefits of pesticides relative to their costs. First, pesticides often have particularly adverse impacts on terrestrial predators (invertebrates and wildlife) that control vertebrate and invertebrate pests, whereas pest species often develop genetic resistance to the pesticides; such phenomena together make pest control more expensive than if non-chemical methods had been used (Marco et al. 1987; van Emden 1989; Steinman 1990; Lee 1991; Dinham 1993; Miller 1994; Holroyd et al. 1995) and have plagued tropical-farming operations (Thomas 1992). Second, although pesticides have promoted crop production, such extra production may create surplus products (as with cocoa in Brazil) that causes market failure as crop-selling prices have dropped (Wright 1994). Third, the increased use of pesticides has not reduced crop losses from pests or caused long-term reductions in disease-carrying insects (Marco et al. 1987; McCoy-Thompson 1990; Steinman 1990); e.g., U.S. pesticide use has increased 33-fold since 1942, despite lower crop losses to pests in the 1940s (31%) than today (37%) (Miller 1994). Rather, increased pesticide use causes increased pest problems (Levins 1974) that require even more pesticide use, causing a vicious circle of ever-increasing pesticide application and tropical deforestation that has aptly been called the 'pesticide treadmill' (Lee 1991; Thomas 1992; Miller 1994) and is akin to drug addiction. Fourth, spray drift of pesticides has been known to catastrophically damage the crops of adjacent tropical farmers, the economic losses not being adequately compensated by the offending farmers (Dinham 1993). Similarly, illegal indoor spraying in the U.S. have often caused poisoning of humans and pets, evacuation and closure of buildings, and increased cleanup costs (taxes) to citizens (Johnson 1997).

TYPES OF PESTICIDES

Pesticides of various types have been developed to control specific types of pests (van Emden 1989; Lee 1991; Miller 1994). Such toxins control insects ('insecticides'), plants ('herbicides'), fungi ('fungicides'), or nematode roundworms ('nematocides'). Early insecticides included toxins that entered pests via the cuticle ('contact poisons'), inhalation ('fumigants'), or ingestion ('stomach poisons'). But because early contact poisons were short-lived and thus not very effective for pest control, modern contact insecticides were developed to be longer-lived ('residual-contact') poisons. Insecticides also evolved from inorganic to organic compounds; the five major types of organic insecticides, in decreasing order of age since first production, include four synthetic compounds ('organochlorines' [chlorinated hydrocarbons],

'organophosphates', 'carbamates', and 'pyrethroids') and natural chemicals produced from plants ('botanicals') or microbes ('microbotanicals') (Haslam 1990; Miller 1994). Herbicides include those that interfere with plant photosynthesis ('contact poisons'), growth-hormone regulation ('systemic poisons'), and symbiotic microbes ('soil sterilants'). Fumigants, which often kill various pests, and organochlorines are particularly dangerous to humans and wildlife because these toxins bioaccumulate in fatty (especially) and other tissues (occur in greater concentrations at higher trophic levels via ingestion of contaminated foods) (Cope 1971; Haslam 1990; Miller 1994), such that human breast milk in the U.S. is still contaminated with DDT (Johnson 1997). For this reason, and given the greater variety of ways that organophosphates can reach and poison insects, organophosphates are the most popular insecticides in use today. Unfortunately, these toxins and other synthetic, contemporary insecticides often interact synergistically and cause extensive human- and wildlife-health problems (Cope 1971; Marco et al. 1987), especially since organophosphates cause greater acute poisoning of chemical-plant workers and tropical farmers than do organochlorines (O'Brien 1990b; Lee 1991; Dinham 1993) because of their chemical similarity to nerve gases (Johnson 1997). Various organochlorines (e.g., DDT, lindane, DBCP, and HCH) that have been used in the tropics are included in 'the dirty dozen' list of hazardous pesticides and are on the list of pesticides that require Prior Informed Consent (PIC) before they can be shipped to other countries, whereas organophosphates that are used in tropical and other LDCs are sometimes on these lists (e.g., the parathion family) or have been considered for inclusion to the PIC list (e.g., monocrotophos) (Dinham 1993).

Although carbamates are generally considered to be faster-degrading than organochlorines and organophosphates, such that bioaccumulation and human hazards are less likely, these insecticides are not as harmless as once thought (Marshall 1985). Indeed, aldicarb (Temik) is much more toxic than DDT or another carbamate (carbaryl = Sevin), especially since aldicarb does not degrade so well in certain environments (e.g., cool, anaerobic or limestone conditions that are common in groundwaters). Nevertheless, aldicarb is well-known for improving the yields of potatoes, cotton, and citrus crops (Marshall 1985).

Likewise, synthetic pyrethroids, the newest development in chemical insecticides, are starting to show toxicity problems. Although these pesticides are less harmful to humans and other mammals than organophosphates, they are relatively more toxic to fish foods (aquatic invertebrates) in Britain (Pearce 1997) and are prone to pest resistance such that biocontrol (see below) is more effective than pyrethroid treatment to control insect outbreaks in India (Sharma 1991). As emphasized by Steinman (1990) and Andrews (1993), pyrethroids and other faster-degrading insecticides are often more toxic and environmentally mobile than the organochlorines that they were designed to replace, and their high biodegradability is a disadvantage when microbes break these insecticides down before they can reach pests (Andrews 1993).

WILDLIFE IMPACTS

Pesticides, and insecticides in particular, often have adverse effects on mammals and especially birds; organochlorines (e.g., DDT and lindane), diazonin, and dimethoate are very toxic examples (Stinson and Bromley 1991; Moul and Elliott 1992; Holroyd et al. 1995). Although herbicides and fungicides are generally less hazardous to wildlife because they are rapidly eliminated from the body and do not bioaccumulate, indirect impacts of herbicides may still be significant via losses of vegetation and insects that provide habitat and food for wildlife (Wolfe 1988; Lee 1991; Stinson and Bromley 1991). Given that raptors feed at higher trophic levels, they are especially vulnerable to bioaccumulation of DDT and other organochlorine insecticides that can cause eggshell thinning and breakage (Cope 1971). In the prairie provinces (Alberta, Saskatchewan, and Manitoba), the four important raptor families that require pesticide management include hawks, falcons, vultures, and owls (Holroyd et al. 1995), the peregrine falcon being an especially vulnerable species (Thomas 1994). Among invertebrates, honey bees (Apis mellifera) and wild bees are especially sensitive to damage by carbamates and other insecticides, the bee extirpations causing losses of honey crops and/or the important ecological function of flower pollination (Marco et al. 1987; Lee 1991; Miller 1994; de Oliveira and de Oliveira Toniato 1995).

It has recently been shown that some neotropical-migrant birds, which breed in North America and fly south for the winter, are victims of pesticide poisoning. Swainson's hawk (Buteo swainsoni), a raptor which breeds and feeds extensively on rodents during summer (May to August) in the grasslands and deserts of the western U.S. and prairie provinces (including Alberta), was once thought to be on the decline because of loss of ripari-

an habitat (cottonwood trees) in these areas (Koford 1993). Indeed, Lee Pengilly, a certified-organic farmer near Stirling, Alberta, who has long relied on the Swainson's hawk to control pest gophers, has noticed a steady decline in the number of hawks visiting her property in recent years and commented that "This is terribly significant to us" (pers. comm., 1997). The hawk, which overwinters mainly in the Pampas region of Argentina in flocks of up to 7,000 birds and roosts in widely scattered groves of imported Australian eucalyptus trees bordering the crop fields, is dying en masse because of contamination with an organophosphate called monocrotophos; this pesticide is ingested when the birds preen their poisoned wings and eat contaminated pests (grasshoppers) (Woodbridge et al. 1995; Anon. 1996b, 1997b; de Benedictis 1996; Line 1996; DiSilvestro 1996). Other insectivorous birds may be dying as well, but are not as noticeable because of the overwhelming numbers of hawks being found (DiSilvestro 1996). Monocrotophos, which has been banned in the U.S. for over a decade and was never legalized in Canada, is well-known for being highly toxic to higher vertebrates, particularly raptors; the pesticide probably should be replaced with a less poisonous, but more expensive, carbamate (e.g., carbaryl) or organophosphate to protect sunflower, alfalfa, corn, and soybean crops (de Benedictis 1996; DiSilvestro 1996; Line 1996). Fortunately, monocrotophos is voluntarily being recalled and will not be sold by CIBA-Geigy and other northern chemical companies (Anon. 1996a, 1997b), although economic pressure from GATT and other international-trade programs is intensifying agricultural production and pesticide use in Argentina (Woodbridge et al. 1995).

Similarly, a songbird that breeds in the western U.S. and prairie provinces, i.e., the dickcissel (Spiza americana), overwinters in Venzuela and has been dying of exposure to organophosphates when it eats seeds from the crops (rice and sorghum) that are being illegally sprayed to get rid of these bird "pests" (Basili and Temple 1995; DiSilvestro 1996). Hence, international cooperation is needed to protect these birds, so that non-lethal control techniques and crop-loss compensation programs can be developed (Basili and Temple 1995). As with the Swainson's hawk, what makes the dickcissel especially vulnerable to extinction is its mass congregations on overwintering grounds, such that pesticides may kill a significant portion of the global population; clearly habitat protection in North America is not enough by itself to protect these and other declining neotropical-migrant birds (Thomas 1994; Basili and Temple 1995; Holroyd et al. 1995; DiSilvestro 1996). Indeed, Swainson's hawk has adapted to agrarian changes in habitat and loss of locust (grasshopper) swarms but may not tolerate further insults from pesticide poisoning (Woodbridge et al. 1995).

ACQUATIC IMPACTS

Further evidence for the worldwide scale of pesticide problems comes from studies of lakes in northern Canada, where fishes are being exposed to pesticides and other tropical pollutants via global air movements, but federal funding of this research has unfortunately been declining due to budget cuts (Pearce 1995). Agricultural pesticides often enter temperate waters, including (a) groundwater via leaching (e.g., of aldicarb) (Marshall 1985) and (b) surface water via runoff (Wauchope 1978), the latter having been modelled by Zitko and McLeese (1980). Such runoff can be minimized by not applying pesticides within 10 m of water bodies and by leaving 10-m riparian-buffer strips of tall vegetation adjacent to these waters so that toxins are sequestered by plants and thus less abundant in runoff (Wolfe 1988). In tropical waters, fish and amphibian kills are common from pesticide contamination (Dinham 1993; de Oliveira and de Oliveira Toniato 1995), such that toxic pollution is considered to be one of the most serious problems impacting pelagic (open-water) ecosystems in marine and freshwater habitats (Aguiar 1995). As with terrestrial wildlife (and for the same reasons), insecticides are often more toxic than herbicides and fungicides (Wolfe 1988; Stinson and Bromley 1991; Moul and Elliott 1992), although certain of the latter two types of pesticides do cause fish kills (Moul and Elliott 1992; Dinham 1993). Especially toxic insecticides to fishes include malathion and rotenone (Stinson and Bromley 1991; Moul and Elliott 1992). These results highlight the differing toxicity and danger of insecticides to terrestrial vs. aquatic ecosystems; e.g., malathion is much more harmful to fish than wildlife resources (Stinson and Bromley 1991).

Because of the potential for bioaccumulation of organochlorines and inorganic toxins (e.g., mercury) by higher trophic levels in aquatic ecosystems, particularly for (a) benthic-insectivorous fishes that feed on contaminated sediments (Jernelov and Lann 1971; Rieberger 1992) and (b) piscivorous (fish-eating) species (Akielaszek and Haines 1981; Rasmussen et al. 1990), especially those that eat older (longer-contaminated) prey fishes (Borgmann and Whittle 1991), analyses of carnivorous fishes and piscivorous birds are recommended for-

such studies (Haslam 1990). Nevertheless, contaminant studies of lower trophic levels (e.g., mosses and aquatic macrophytes) are often performed because plants can accumulate heavy metals and other toxins (Kelly et al. 1987; Haslam 1990); such a research program has recently been undertaken in the Bahamas to monitor tropical seagrasses for contamination by pesticides and other pollutants (Anon. 1994b). Fortunately, not all pesticides bioaccumulate in aquatic food webs (Cope 1971), in particular because aquatic plants often accumulate toxic and radioactive chemicals in higher amounts than do animals (higher trophic levels) (Davis and Foster 1958; Newman and McIntosh 1989). Besides accumulation of DDT and other toxins from foods, aquatic animals also absorb contaminants directly from the water column (Jernelov and Lann 1971; Eberhardt et al. 1977).

Organochlorines such as DDT not only kill certain temperate-fish species more than others (Surber 1946), but they also affect the foods available for these fishes (Cope 1971). Indeed, DDT spraying is known to cause increased drift (emigration) of aquatic insects and paralysis of non-insect aquatic invertebrates such as crayfishes, making these contaminated animals temporarily very vulnerable to predation by temperate, drift-feeding fishes such as trout (Salmonidae) and shiners (Cyprinidae) until these food resources are depleted by DDT below natural levels (Hoffman and Surber 1945; Surber 1946; Adams et al. 1949). Based on their pelagic-ecosystem models, O'Neill et al. (1982) concluded that indirect effects complicate toxin impacts on aquatic food webs, since a given trophic level might be (a) enhanced by toxins if their predators are disproportionately impacted or (b) severely harmed by disproportionate losses of foods.

Indeed, the indirect effects of pesticide use can sometimes be beneficial to aquatic ecosystems. The spraying of a pesticide defoliant (Agent Orange) in Vietnam, which was done by the U.S. military to clear camping areas and destroy enemy cover, caused a conversion of riparian (streamside) plant vegetation that led to unexpected fisheries effects (Woodwell 1970). That is, bamboo stands replaced tropical-forest vegetation, such that forest nutrients were lost to streams to cause increases in algal production and fishing success; eutrophication likely benefitted the aquatic food web (including: invertebrate foods for fishes) because the herbicides were not toxic to at least some fish species. Nevertheless, too much nutrient enrichment (e.g., sewage pollution) is known to cause increases in algal species that are more resistant to various human impacts, including DDT contamination, that the natural algal assemblage cannot tolerate (Woodwell 1970). That is, human-caused pollution may benefit super-tolerant species at the expense of sensitive species, with resulting loss of aquatic biodiversity (Woodwell 1970; Vadas 1997).

Amphibians are likely to be especially sensitive to pesticides and other pollutants, given that they have permeable skins, are dependent on both terrestrial and aquatic habitats, and the adults feed higher in the food chain (Barinaga 1990). Indeed, frogs and other amphibians have been declining in both temperate and tropical environments (Barinaga 1990; Wake 1991) and mass deformities have recently been discovered in North American frogs (Hallowell 1996; Anon. 1997d), probably due to both local (site-specific) and global (widespread) factors. While habitat loss is a likely cause of much of these reductions, amphibian losses have also been seen in pristine habitats (Barinaga 1990; Wake 1991), such that other factors (e.g., errant pesticides) that cause deformities and thus mortality may also be involved (Hallowell 1996; Anon. 1997d).

HUMAN IMPACTS

In developed countries, most chemicals registered for domestic use undergo testing to determine "safe" exposure levels, a process known as 'risk assessment' that supposedly balances health and economic concerns (Steinman 1990). There is a segment of the human population, however, for whom risk assessment is particularily meaningless, i.e., chemically sensitive people who suffer immediate impacts from exposure to minute levels of compounds (O'Brien 1990a). Indeed, in temperate areas such as California, pesticide exposure (via ingestion, inhalation, and/or skin absorption) is known to be particularly damaging to fetuses, children, senior citizens, certain ethnic groups, people with skin cuts or other dermal problems, and people weakened by sickness or disease (Katten 1990; O'Brien and Marquardt 1990; Steinman 1990; Thrupp 1990; Johnson 1997), such that pesticide products should not be formulated or packaged to be attractive to children (Koppell and Sevinsky 1994). These health problems are exacerbated in tropical and other LDCs, because of the greater frequency of poor health (via malnutrition, overexertion, etc.), illiteracy (such that people cannot read pesticide-warning labels), and poor economic status and inadequate pesticide regulations (such that safety precautions, training, and equipment are minimal or lacking) (Thrupp 1990; Thomas 1992; Matos et al. 1987); such problems are particularly noticeable for tropical workers using herbicides on cotton plantations (de Oliveira and de Oliveira Toniato 1995). Indeed, many pesticides that are banned, unreg-

istered, of restricted use, or voluntarily cancelled for use in developed countries are utilized in the tropics and other LDCs because of inadequate knowledge or inability to pay for safer pesticides, thus promoting much greater poisoning and death of humans (Thomas 1992; Dinham 1993; de Oliveira and de Oliveira Toniato 1995). Moreover, the differing climate of the tropics often intensifies pesticide problems, or at least changes circumstances relative to temperate countries. The hot, humid climate makes worker protection via adequate clothing impractical (Thrupp 1990; Dinham 1993; de Oliveira and de Oliveira Toniato 1995) and promotes the biological uptake (and danger) of pesticides (Thrupp 1990). High temperatures and intense solar radiation also accelerate breakdown of pesticides, thus reducing chemical shelf lives (Thrupp 1990), whereas high humidity also facilitates chemical reactions that create new toxins and causes rusting (and thus leaking) of barrels containing pesticides (Thrupp 1990). In addition, the intensity of tropical rainstorms further promote pesticide spread in terrestrial and aquatic ecosystems via enhanced runoff (Thrupp 1990).

Pesticide deaths (e.g., from monocrotophos poisoning) are common in LDCs, both via deliberate (suicidal) and accidental ingestion, the latter occuring when pesticides are mistaken for food or drink (Dinham 1993). Nonlethal poisoning is even more common among pesticide workers, and even unexposed workers have shown elevated toxin levels and neurological problems via bioaccumulation of organochlorines (Minelli and Ribeiro 1996). DBCP is a well-known organochlorine that caused permanent sterility in workers at Californian chemical plants and Costa Rican banana plantations during the 1970's (O'Brien and Marquardt 1990; Thrupp 1990; Thomas 1992; Vandermeer and Perfecto 1995).

Various medical symptoms resulting from worker acute exposure to organophosphate and other, newer insecticides used on cotton and other crops have become apparent in temperate and tropical countries (Matos et al. 1987; O'Brien 1990b; Steinman 1990; Lee 1991; Dinham 1993). These include flu-like symptoms, fevers, trembling, excessive sweating, nausea (including lack of appetite), dizziness, fatigue, irritability, diarrhea, vomiting, colds, rhinitis (stuffed or runny nose), nose-bleeds, throat and eye irritation (including tear production), blurred vision, wheezing, coughing, sputum production (of saliva and phlegm), respiratory problems (e.g., shortness of breath, burning sensations, and worsening of pre-existing pulmonary diseases), various aches (of the head, back, stomach, kidney, and joints), skin rashes, parasite infections (which may cause numbing of the extremities), and a general feeling of sickness/malaise. Less common problems include convulsions and coma, although several tropical workers have collapsed on farm fields because their supervisors ignored their complaints of sickness.

Health problems caused by chronic exposure to these pesticides have also been observed in temperate and tropical countries (Matos et al. 1987; O'Brien 1990b; Steinman 1990; Lee 1991; Dinham 1993; Johnson 1997). These include permanent scars, loss of fingernails and limbs, liver and kidney ailments, various psychological symptoms (e.g., anxiety, sleep disorders, depression, and intense headaches), vision problems (including retinal damage), and impaired mental abilities (for memory, thinking, and communication). Some evidence also suggests that long-term pesticide exposure causes genetic damage, cancer, and birth defects. Matos et al. (1987) provided evidence (from Argentina workers) that the affected organ systems, in decreasing importance, are the (a) central-nervous, (b) appendicular (arm/leg), (c) digestive, respiratory, and skin, and (d) reproductive systems.

In some tropical countries, people have been poisoned via exposure to byproducts of pesticides. In Bhopal, India, exposure to deadly gases (methyl isocyanate and possibly hydrogen cyanide) that were being used to manufacture carbaryl has caused extensive death and injury (Mukerjee 1995; Kates and Clark 1996). The latter included vision problems (e.g., blindness and burning eyes) and respiratory ailments (e.g., choking lungs), as well as gastrointestinal, other internal-organ (liver and kidney), neurological, neuromuscular, psychological, and reproductive symptoms in children and/or adults. Reproductive abnormalities included miscarriages and early infant death, as well as infant limb, heart, and neurological problems. Unfortunately, Union Carbide and the India government (a) lacked a contingency plan to combat damage from gas leaks, (b) gave inadequate compensation for injuries (relative to death cases), and (c) suppressed antidote treatments for cyanide poisoning to avoid acknowledgment of the potential leak of such a deadly gas (Mukerjee 1995; Kates and Clark 1996). Indeed, there was no antidote for methyl isocyanate or education of citizens to minimize poisoning; much of the tragedy could have been avoided if people had covered their faces with wet cloths and evaculated the city (rather than running towards the plant in curiosity when the gas-leak alarm had sounded). Moreover, people still inhabit the city despite the likelihood that toxic-breakdown products (e.g., dichlorobenzenes) are still present

(Mukerjee 1995).

Similarly, the spraying of Agent Orange during the Vietnam War has caused health problems in many of the U.S. veterans who were exposed to this defoliant, which was composed of two phenoxy herbicides (2,4-D and 2,4,5-T) and an extremely toxic organochlorine byproduct, i.e., dioxin (Fackelmann 1984, 1993; O'Brien 1990a; Van Strum and Merrell 1990; Begley 1992; Stone 1992; Hanson 1993a,b; Eisman and Raineri 1996; Johnson 1996). Based on animal testing and exposure data from veterans and civilian (agricultural and industrial) workers, dioxin and the other components of Agent Orange have together caused skin disorders (e.g., chloracne), ulcers, liver and heart disease, immunological problems, and various cancers in adults, as well as birth defects (e.g., neurological and reproductive problems) in the infants of exposed adults; indeed, dioxin often bioaccumulates in human breast milk and is ubiquitous in human tissue in developed countries. Fortunately, compensation of veterans is occurring, although the U.S. military has disputed the health effects (including its falsification of results in a health report) because the toxic impacts of dioxin have been delayed and the military does not want to acknowledge that it used chemical warfare in Vietnam and Laos (Work et al. 1984; Van Strum and Merrell 1990; Eisman and Raineri 1996; Johnson 1996). Unfortunately, dioxin is present in various herbicides and other pesticides (Eisman and Raineri 1996), even though the chemical bioaccumulates and is one of the most highly toxic substances known to humans (O'Brien 1990a; Van Strum and Merrell 1990; Begley 1992). Although risks are now downplayed by the U.S. EPA because of data fudging (including strategic manipulations and omissions of data) by chemical companies (i.e., Monsanto in the U.S. and BASF in Germany) and the U.S. military (Van Strum and Merrell 1990), it is likely that dioxin will someday be regarded with the same fear that DDT has achieved.

Given the particular sensitivity of people in tropical and other LDCs to pesticide poisoning, particularly strict pesticide standards for risk assessment need to be enforced to prevent further tragedy. All risk assessment, in fact, must be reviewed and rethought (Steinman 1990) in light of increasing evidence for cumulative impacts of low-level, long-term exposure to a variety of chemicals. A 1996 study from the Tulane-Xavier Center for Bioenvironmental Research in New Orleans suggests that PCBs and organic pesticides, long believed to be harmless at the levels to which humans are routinely exposed, actually show a stunning increase in toxicity when combined (Anon 1997c; Rodale 1997). Synergistic reactions do not allow for simply looking at the risk of each individual factor and adding them together; due to synergy, two plus two can equal five, ten, or much more. In the Tulane-Xavier study, simultaneous exposure to only two chemicals turned out to be more than 1000 times more dangerous than the same dosage of either chemical alone (Anon 1997c; Rodale 1997). As emphasized by Johnson (1997), the past use of safety factors in the U.S. (e.g., 100-fold reductions in allowable pesticide concentrations compared to toxicity tests) may not be adequate if synergism occurs among contaminants.

Even herbicides lacking dioxin may cause poisoning of humans, via their presence in drinking water and ability to cause mammalian cancer (Johnson 1997). A notable example is atrazine, which is often used on corn crops in the U.S. but is banned in several European countries (Johnson 1997).

ALTERNATIVE PEST CONTROL STRATEGIES

Given that standard methods for applying pesticides are often inefficent, in that low amounts of toxins (often 25-50%) actually reach target fields from aerial application (Johnson 1997) and very small proportions (often under 1%) of pesticides actually contact target pests in temperate and tropical habitats (Pimentel and Levitan 1988; Thomas 1992; Miller 1994), this leaves over 99% of the poison to contaminate soil, water, and air resources and kill species which normally prey on the target pest (e.g., the Swainson's hawk eating the grasshoppers targeted for monocrotophos). Clearly, improved techniques need to be developed to more directly apply pesticides and thus minimize ecosystem impacts without impairing pest control (Pimentel and Levitan 1988); as one might imagine, it is not difficult to find more efficient, less costly, and safer alternatives to organic pesticides.

Organic farming, irradiation of food, development and use of resistant crops (e.g., via biotechnology), physical/mechanical control, cultural control (landscape design), integrated-pest management (IPM), and biocontrol are other methods that can effectively replace heavy pesticide-use stategies and (were it not for subsidies to farmers using pesticides) are often less expensive to implement than heavy fertilizer/pesticide programs (Marco et al. 1987; Gradwohl and Greenberg 1988; van Emden 1989; Lee 1991; Stinson and Bromley 1991;

Dinham 1993; Miller 1994). Unfortunately, irradiation of foods may cause radioactive dangers to humans and is not a feasible alternative to pesticides (Steinman 1990; Miller 1994). The goal of cultural control is to increase the spatiotemporal diversity of vegetation to minimize pest habitat and aggregations but provide good habitat for pest predators; use of crop rotation, hedgerows, and crop poly- rather than monocultures are all important techniques, albeit they are often not yet practical for large-scale farming (van Emden 1989) because the techniques do not always work as planned (Forman and Godron 1986). Cultural-control techniques for small landowners include use of xeriscaping and naturalization (i.e., low-water gardening with an emphasis on planting native species), as well as "weed appreciation" (which might involve exploitation of weeds for their food value) (Ash et al. 1997). The goal of IPM is to utilize various methods of pest control, with more emphasis on biocontrol than pesticides, although complete elimination of pesticides may not be feasible if crop losses are to be avoided (Marco et al. 1987; van Emden 1989; Miller 1994). Unfortunately, IPM has been underused, given the greater biological and other knowledge necessary to implement this methodology and the political power of the chemical industry to keep the status quo.

Biocontrol, or biological control, is the use of natural enemies (predators, parasites, and pathogens) to keep pest populations below economically damaging levels. Rather than killing natural predators of pests, we ought to enlist them; without human help or interference, the world's 30,000 known species of spiders kill more insects yearly than insecticides do (Miller 1994). Likewise, it has been estimated that during 10 days of feeding nestlings, a pair of adult wood warblers can remove grasshoppers from up to a million leaves (Thomas 1994). Indeed, biocontrol via parasitoid insects, as well as natural-organic pesticides made from virus-infected insect pests, have been shown to work as well or better than synthetic insecticides in the tropics, e.g., on cassava crops (Stevens 1993; Damsker 1994). Likewise, a botanical pesticide called neem, which is made from the seeds of a tropical tree species, is purported to yield good control of insects and other pests, as well as to provide medical and other human benefits (Anon 1992; Damsker 1992a,b); impacts on non-target biota appear to be more limited than for synthetic pesticides (Damsker 1992b). At least in temperate ecosystems, biocontrol of pest insects via the microbe Bacillus thuringensis (BT) has not had adverse impacts on fish and wildlife resources (Stinson and Bromley 1991; D.J. Orth, Department of Fish and Wildlife Sciences, Virginia Tech, pers. comm., 1994). To control tropical malaria, biocontrol and management of mosquito (vector) habitat (e.g., via wetland drainage) make more sense than use of DDT, which is (1) contaminating the aquatic food web in the Amazon River (McCoy-Thompson 1990) and (2) becoming less effective via increasing mosquito resistance to DDT (Willoughby 1976).

Unfortunately, biocontrol is often difficult because ecologists have not been in agreement over the best characteristics of natural enemies; general rules of thumb for choosing effective natural enemies of invertebrate pests include (a) use of several parasite species or polyphagous (generalized) or facultative hyperparasites (that parasitize both parasites and pests) to more completely decimate pest species (Beddington and Hammond 1977; May and Hassell 1981); (b) avoidance of specialized, obligate hyperparasites, i.e., species that allow increases in pest populations because they can only parasitize potential parasites of the pest species (May and Hassell 1981); and (c) avoidance of early-acting parasites that allow pest increases by attacking the pest before the latter is subject to density-dependent impacts (i.e., effects that are especially likely if pests become overpopulated) (May et al. 1981). More controversial is whether natural enemies should be polyphagous or specialized (monophagous) in feeding habits; whereas specialized parasites are considered to be more likely to stabilize and control pests because they depend solely on them (Levins 1974), generalized predators are often able to decimate pest populations without destroying themselves because they can switch to other foods (Murdoch et al. 1984, 1985). Clearly, ecological knowledge of natural-enemy and pest species is necessary to achieve adequate control of agricultural pests.

Biological information is also necessary for several other pest-control methods, including birth-control, pheromonal (sex-attractant), and hormonal methods to disrupt insect life cycles and thus limit pest reproduction (van Emden 1989; Lee 1991; Miller 1994).

ACTION PLAN FOR GOVERNMENTS

Chemical companies came under intense scrutiny following the disastrous gas leak in a Union Carbide pesticide plant in Bhopal, India, on Dec. 3, 1984; the leak killed at least 6495 people and seared the eyes and lungs of another 100,000 (Mukerjee 1995; Kates and Clark 1996; Selcraig 1997). This public-relations nightmare worsened nine months later when, after assurances by U.S. companies that such a disaster could never happen in America, a Union Carbide plant in Institute, West Virginia, had a potentially catastrophic leak of a carbamate (aldicarb oxime) that required short-term hospitalization of several workers (Marshall 1985; Selcraig 1997). Aldicarb came under further fire after several Californians were poisoned from eating illegally sprayed watermelons (Marshall 1985). These accidents spurred the U.S. Congress in December 1985 to pass (by a close vote of 212 to 211) a law that former U.S. EPA Director William Reilly called one of the most important laws of the last 20 years, i.e., the Toxics Release Inventory (TRI) (Selcraig 1997). TRI is a modest program to increase protection of citizens and the efficiency of chemical companies, by allowing citizens to (a) obtain information on the use and transport of chemicals by industries and (b) sue law-breaking companies. Indeed, public exposure of bad polluters has done more to curb toxic pollution and industrial costs than have previous monetary penalties vs. the chemical industry. Fortunately, TRI is now being improved to include previously exempt industries under its jurisdiction (Selcraig 1997).

The accident at Bhopal also stimulated awareness of, and improvements in, safety standards in North America and especially in India and other LDCs (Kates and Clark 1996; Selcraig 1997). Together with the 1986 discovery of a hole in the Antarctica ozone layer, the Bhopal tragedy has compelled U.S. and Canadian chemical industries to rehabilitate their public image by practicing "Responsible Care" (Amato 1993; CCPA 1995; DCC 1996). The latter programs, in conjunction with increased public concern and government funding of environmental-chemistry research, have led to (a) 41% reductions in U.S. industrial emissions between 1987 and 1991, despite a 10% increase in industrial production (Amato 1993); and (b) 50% reductions in Canadian industrial emissions between 1992 and 1994, including an 84% curtailment of discharges to water (CCPA 1995). Monsanto has shown especially great curtailment of emissions in the U.S. (90%) via a combination of plant closures, chemical recycling and frugality, and innovative chemistry and engineering (Amato 1993). Via increases in efficiency, recycling, and reuse at their plants, Dow Canada has reduced energy use per unit production by 50% between 1990 and 1995 and significantly curtailed air, land, and water emissions and waste production; notably, Dow's plant in Sarnia, Ontario, has reduced organic-toxic discharges into the St. Clair River by 96% between 1989 and 1995 and plans to eliminate even these effluents by the year 2000 (DCC 1996). These preventive-management strategies, along with replacement of toxic chemicals with less hazardous ones, have actually saved chemical companies money because they avoid Superfund and other messy cleanups (Amato 1993). Union Carbide has also called for heavier fines for misuse of carbamates, given that these pesticides often cause human poisonings from illegal sprayings (Marshall 1985). Unfortunately, despite the TRI and Responsible Care programs and the associated cost savings for chemical companies, U.S. industries continue to fight and exploit loopholes in TRI regulations (Selcraig 1997) and to engage in false advertising of pesticide "harmlessness" that has led to lawsuits and fines against companies producing lawn-care products (i.e., ChemLawn Services Corporation, Dow Elanco, and Chevron Chemical Company) (Koppell and Sevinsky 1994).

Pressed into action by these events and the ensuing public pressure, chemical companies in developed nations have made enormous strides in recent years. First, community activists in Texan and Califonian cities, armed with TRI and Right-to-Know legislation, negotiated agreements with local chemical plants to allow citizen groups to (a) perform regular environmental and safety inspections of the plants with their own experts and/or (b) receive company funds to facilitate public-health protection (Selcraig 1997). Second, Dow Canada has committed itself to community dialogue and partnerships to benefit public education and improve community safety (DCC 1996). Third, when municipal workers in LaSalle went on strike in 1994, the city's hazardous-waste collection day was almost cancelled (CCPA 1995). Fortunately, Monsanto employees quickly stepped in to organize the event, initiative which they had also shown two years earlier when they had started the program to collect household hazardous wastes (CCPA 1995). These considerable improvements taking place across North America, however, contrast with the limited improvements unfolding in the southern hemisphere. Indeed, in November 1977, the U.S. EPA cancelled registration for most uses of DBCP because the pesticide sterilized 35 workers at a formulating plant in Occidental, California (O'Brien and Marquardt 1990). Dow Chemical Company and the Shell Oil Company continued to ship it to Costa Rica, however, for use on Standard Fruit Company banana plantations. Twelve years later, Shell and Dow argued in a Texas courtroom that it would

be more convenient for them to face personal-injury claims in Costa Rica (rather than in Texas) for the medical problems caused by DBCP, including sterility, of 82 Costa Rican workers. In ruling against their claim of *forum non conveniens*, Texas Supreme Court Justice Doggett commented:

"Our citizenry recognizes that a wrong does not fade away because its immediate consequences are first felt far away rather than close to home... The 'doctrine [Shell and Dow] advocate has nothing to do with fairness and convenience and everything to do with immunizing multinational corporations from accountability for their alleged torts abroad... The banana plantation workers allegedly injured by DBCP were employed by an American company on American-owned land and grew Dole bananas for export solely to American tables. The chemical allegedly rendering the workers sterile was researched, formulated, tested, manufactured, labeled and shipped by an American company in the U.S. to another American company. The decision to manufacture DBCP for distribution and use in the Third World was made by these two American companies in their corporate offices in the U.S. Yet, now Shell and Dow argue that the one part of this equation that should not be American is the legal consequences of their actions... Some U.S. multinational corporations will undoubtedly continue to endanger human life and the environment with such activities until the legal consequences of these actions are such that it becomes unprofitable to operate in this manner... The doctrine of *forum non conveniens* is obsolete in a world in which markets are global and in which ecologists have documented the delicate balance of all life on this planet." (O'Brien and Marquardt 1990, p. 44).

Ultimately, protection of tropical rainforests from agricultural deforestation will require that local people have economic stability via land and food security, which includes prevention of land destruction and exploitation of workers by agribusinesses (Gradwohl and Greenberg 1988; Anon. 1993; Wright 1994; Vandermeer and Perfecto 1995). Although human-population control, economic boycotts of wood products from irresponsible logging operations, and boycotts of tropical crops that require heavy pesticide use (e.g., bananas and coffee) may contribute towards solving of the problem, the central issue is correction of social injustice via political reform. Indeed, although logging operations may promote agricultural deforestation and urbanization of tropical rainforests, the major stimulant of large-scale deforestation is economic desperation of workers laid off by plantations when business is not so good (which could ironically be exacerbated by crop boycotts); such people will even (and understandably) enter and set up farms in wildlife preserves to make ends meet for their families. Tropical rainforests are moderately resilient and not overly fragile in the face of traditional logging and agricultural operations; rather, modern, large-scale agriculture (including beef ranching) and urbanization are what destroy these forests and/or promote heavy pesticide and fertilizer usage (Gradwohl and Greenberg 1988; Vandermeer and Perfecto 1995), thus leading to a cascade of species extinctions and irreversible loss of the rainforest ecosystem (Bretsky et al. 1972; Gomez-Pompa et al. 1972). For this reason, and given that trees often grow better than herbaceous crops in acidic, nutrient-poor tropical soils, promotion of agroforestry (tree crops and their associated plant and animal resources) in a mosaic landscape of parks and human development may adequately protect wildlife habitat and minimize chemical (pesticide and fertilizer) use without destroying the livelihood of local people (Gradwohl and Greenberg 1988; Vandermeer and Perfecto 1995). Such agroforesty and landscape management may also promote watershed protection (relative to large-scale agriculture) by reducing soil erosion and water pollution (Easter et al. 1986). Involvement of local people from LDCs in these management decisions will go a long way towards reducing agricultural deforestation and pesticide contamination of tropical rainforests (Easter et al. 1986; Thrupp 1990); the emphasis needs to be on sustainable agriculture and alternatives to pesticides rather than merely education and training in pesticide safety that the chemical industry now promotes (Dinham 1993). Hence, citizens in developed countries should put pressure on their governments to promote social, political, and economic stability and democracy in the LDCs that they choose to deal with, in contrast to present U.S. policy to promote agribusiness at the expense of peasants (Thomas 1994).

But political reform will also be necessary in developed countries to reduce global pesticide problems. Indeed, the circle of poison needs to be terminated, given that these countries now allow the making and export of dangerous pesticides to LDCS, the pesticides coming back to the developed countries via food imports, neotropical-migrant birds, and global air circulation (Steinman 1990; Thomas 1992; Miller 1994). Indeed, if these countries were confronted with explicit imports of toxic or nuclear wastes from other countries, most citizens would likely object to such direct, point-source exposure to hazardous materials. The U.S. government is well-known for inadequately protecting its citizens against pesticides and other toxic and radioactive contaminants

(Steinman 1990), whereas the Canadian government has minimal ability to ban pesticide formulation and export although the Canadian Environmental Protection Act may improve control if scientific information is given greater emphasis than political concerns (Kathleen Cooper, Canadian Environmental Law Association, Toronto, Ontario, pers. comm., 1997). The allowance of multinationally based chemical companies by these developed countries is also disturbing; as Dee Parkinson-Marcoux, President and CEO-elect of CS Resources, a Calgary oil company asserts, "For a company to move to another jurisdiction to avoid following the rules they abide by at home is a cop-out of the highest order" (pers comm., 1997). The Pesticide Export Reform Act (PERA) of 1990 in the U.S. would have contributed greatly to such political reform, including improvements in PIC agreements that allow receiving countries to (a) prevent entry of dangerous pesticides from chemical companies, (b) develop effective pesticide-regulation programs, and (c) receive education on alternatives to pesticide use (O'Brien and Marquardt 1990); indeed, present PIC regulations have sometimes been overridden in court so that the chemical industry can continue to profitably dispose of obsolete, dangerous pesticides to LDCs (Dinham 1993). The bill also would have increased the competitiveness of U.S. farmers, who are not able to use such effective, but dangerous pesticides to increase crop production (O'Brien and Marquardt 1990). Unfortunately, both the U.S. EPA and the National Agricultural Chemicals Association opposed the bill (O'Brien and Marquardt 1990), such that PERA never became law. If such legislation were to be seriously considered again (and North American citizens should put pressure on their governments to make sure that this happens), the U.S. government should be required to (a) accelerate its program to regulate older pesticides to the same, improved standard that it now deals with newer pesticides (Miller 1994; Johnson 1997), (b) better control pesticide labelling so that inaccurate and misleading safety information is avoided (Dinham 1993), and (c) test greater amounts of imported foods (than the present 1% level) for illegal pesticides (Steinman 1990; Johnson 1997) such as DDT that still contaminate U.S. food products (Work et al. 1984). Nevertheless, simply banning export of dangerous pesticides to LDCs may ironically intensify pesticide problems, if the richer LDCs decide to make the pesticides themselves rather than import safer, but more expensive, pesticides from developed countries (Dinham 1993). Clearly, economic incentives to increase the use of safer (relative to dangerous) pesticides need to be implemented by developed countries.

One recent U.S. law passed by President Bill Clinton, i.e., the Food Quality Protection Act, is notable in providing greater protection to citizens vs. pesticides (Johnson 1997). This law requires (a) that toxicity to children be taken into account during pesticide testing and (b) that major grocery stores provide pesticide-warning labels on products. This federal law should provide consistency in product labelling across states, which presently vary in labelling requirements (Johnson 1997).

As emphasized by Kates and Clark (1996), prevention of disasters such as the Bhopal gas leak, spread of infectious diseases, and ozone depletion require that governments better prepare themselves against unexpected surprises, via (a) the monitoring of hazards in both expected and unexpected areas; (b) better testing of pesticides and other toxins before they are approved for commercial use; (c) better research to understand the causal mechanisms that lead to environmental problems (e.g., inadequate safety regulations at Bhopal, human overpopulation for diseases, and use of overly dangerous chemical products to the ozone layer); and (d) risk analysis and management. The latter requires research programs to allow early detection of problems and formulation of effective contingency plans should hazards arise.

In Alberta, policies to reduce pesticide use have been implemented, including adoption of (a) an IPM program in Calgary (Reichardt 1997); (b) a unified-certification program for provincial organic (pesticide-free) farmers, so that consumers can be assured of uniform product quality (Thierrin 1997); and (c) bans on pesticides for cosmetic purposes in Drayton Valley (Ash et al. 1997). In addition, potential changes in pesticide policy are being considered in larger Alberta cities, including Calgary, Edmonton, and Lethbridge (Ash et al. 1997).

ACTION PLAN FOR CITIZENS (Environmentalists & Consumers)

Finally, although U.S. citizens are generally concerned about pesticide residues in foods and other toxic wastes (Work et al. 1984), consumers in developed countries will need to greatly alter their grocery-shopping habits to reduce these pesticide problems. Steinman (1990) and Rauber (1997) emphasized that buying fruits and vegetables (e.g., berries and cherries) out of season, i.e., in the winter, causes increased environmental problems via importation of crops from Central America and the southern hemisphere; not only is more energy required for food transport

over greater distances, but the products are often grown under heavy pesticide and fertilizer conditions. Non-organic, waxed fruits and vegetables should be avoided (Steinman 1990) because washing and (sometimes) peeling of these products may not remove the pesticides (Long 1992). Steinman (1990) provided lists of foods that are low, moderate, and high in pesticide contamination, and emphasized that vegetarianism is a good idea because red-meat, dairy, egg, and freshwater-fish products often have high toxin levels via bioaccumulation in fatty tissues; other dangerous products include many prepared foods (particularly junk foods), additives, and beverages (particularly alcohol). Filtration of tap water, to remove pesticides and other contaminants, is recommended even in developed countries, and commercial household products should be avoided in favor of more benign products for (1) cleaning (e.g., lemon juice, distilled white vinegar, salt, borax, hot water, and mild detergents), (2) deodorizing (e.g., baking soda and natural botanical fragrances), (3) restoring of furniture (e.g., mineral- and vegetable-oil products, mayonnaise, and toothpaste), and (4) pest killing (e.g., baking soda, borax, and boric acid).

Buying crops that have not been improved in appearance via pesticides, and better yet, buying organically grown products, are important consumer mechanisms for reducing global pesticide use and contamination (O'Brien 1990a; Long 1992; Anon. 1994a; Johnson 1997; Rauber 1997); certified-organic products and foods from 'transitional' (newly) organic fields are better than 'sustainable-agriculture' and IPM products (Steinman 1990). Other benefits of organic products include (a) reduced loss of soil, water, energy, and rainforest resources and global biodiversity; (b) protection of small-time farmers who cannot compete with pesticide- and fertilizer-driven agribusinesses; and (c) better-tasting foods (Anon. 1994a). Indeed, Jukofsky and Willie (1993) argued for the labelling of banana products that are grown under environmentally friendly conditions, whereas O'Brien (1990a) called for labelling of food products to identify the pesticides used on them. Indeed, Maine law requires grocers to advertise which post-harvest fumigants have been used on food products (O'Brien 1990a). Such labelling should allow consumers to make effective, environmentally responsible choices when shopping. Ultimately, effective control of pesticides will require monetary democracy, in which consumers vote with their dollars (Miller 1994). Given the growing human population and use of pesticides, Rachel Carson's apocalyptic vision of a 'silent spring' is still a realistic concern (Marco et al. 1987).

WE OFFER 12 TIPS FOR CANADIAN CITIZENS

1. Buy organic. Support agriculture which works with nature, rather than fighting against it. Don't buy bananas unless they are certified organic.
2. Buy from local producers, to support nearby farmers and reduce energy wastage from unnecessary transportation of goods. This can be facilitated by buying fruits and vegetables in season.
3. Phone or write your favorite coffee shops, asking them to supply organically grown coffee.
4. Write to companies, to let them know why you are supporting them or why you have stopped patronizing them.
5. Write to the federal Minister of Health and your own MP urging that Canada review our pesticide laws. Insist that the burden of proof be shifted to manufacturers to demonstrate that their products are safe. To a disturbing degree, the current system assumes that chemicals are innocent until proven guilty, an approach that has often damaged ecosystems and made people sick.
6. Practice organic or IPM gardening and lawn-care techniques at home; this will teach yourself and your family in a tangible, practical way to question the benefits or "necessity" of using chemicals.
7. Take part in Calgary's campaign to reduce pesticide use. Phone (403) 286-6473 or e-mail raphael@ecobio.com.
8. Become a shareholder with the Community Shared Agriculture organization. Pay approximately $300 in April, and you will receive 12 to 16 weekly deliveries of local, organically grown produce. The farmer can then buy the year's seeds without taking a bank loan. In a bad year, all shareholderers take the risk; in a good year, you will be swamped with tasty, healthy food. Since some shareholder agreements also ask that everyone put in 1-2 days working in the garden, this is also a great way for city folk to connect with nature. Phone (403) 283-0341.
9. Given the potential for bias by chemical companies and their consultants (Van Strum and Merrell 1990; cf. Vadas 1994), support initiatives for independent (e.g., university) health assessments of pesticide effects.
10. Write Environment Canada officials to convince them to promote organic farming on the agricultural lands that they manage, e.g., the Alaksen and other wildlife sanctuaries administered by the Canadian Wildlife Service in British Columbia.
11. Detoxify your body and thus prolong your healthy life by undertaking good diet and sweating (exercise and sauna-bath) programs; use of vitamin supplements and antioxidant foods is particularly important (Steinman 1990).
12. Become further educated about pesticide pollution and regulations by contacting citizen environmental organizations and government agencies; Johnson (1997) and Selcraig (1997) provide relevant surface-mail and internet addresses.

In summary, we close the report by asking a question; would you accept money from someone to poison you? If you are not buying organic products simply because pesticide contaminated products are cheaper, then the answer is unfortunately "yes".

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