A Fork in the Road

Pesticides and Our Future

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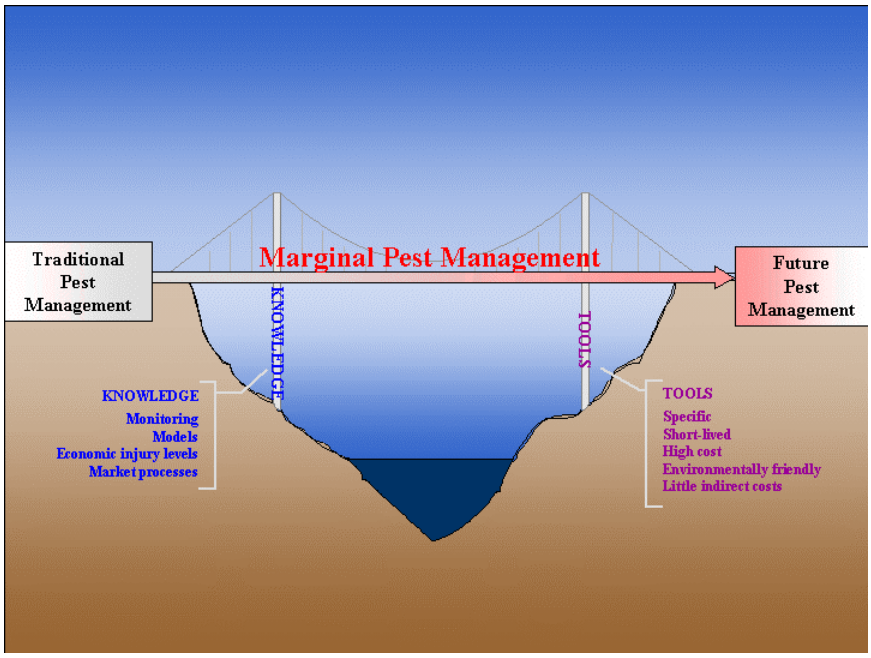
Pesticides: Foe or Ally

Our dependence upon pesticides has intricately shaped the society in which we live. Yet, the relationship between mankind and pesticides has come under many pressures over the years. The bonds holding the two together have become tested and weakened, shifting the way in which we see the role of pesticides. In essence, much of the world has come to abhor the use of pesticides, resulting in an intense effort to eliminate our dependence upon them. Unfortunately the war against pests, the organisms that plague our lives, continues. Pesticides, formerly our most effective weapon in this war, may no longer be a viable option for our future.

The following is an attempt to illustrate the trends coming to bear in the world of pest management and the need, perhaps, for a new strategy in the war on pests. As you will see, many arguments have been stacked against the use of pesticides - our predominant strategy in the control of pest organisms. In order to maintain our reduced-pest standard of living, the world of pest management must take these arguments into account and find an accommodating strategy if the future of pest management is to grow. Our answer to the pesticide problem is the use of marginal pest management. We define marginal pest management as the knowledge, strategies, tactics, and tools that are employed today on the fringes of pest control including (but not limited to) understanding the physiology of the organisms to be controlled, timing pesticide alternatives use to correlate with increased pest activity, utilizing available monitoring and trapping techniques, and developing environmentally friendly attractants and repellants.

In order to progress in the world of pest management, we must find leverage between it and the arguments against pesticide use.



Each of the following chapters is an examination of an issue surrounding pesticide use. Hopefully, they will allow the reader to notice that the path pesticide use has left us yields only one true weapon in the war on pests: marginal pest management. To help the reader, we include a summary statement with a 'wedge-map' at the end of each chapter in illustration of our arguments leading to the need for a new pest control strategy.

Chapter 1

The Wonders of Pesticides

A Pesticide Definition

Pesticides are the chemicals (bacteriacides, fungicides, herbicides, nematicides, rodenticides, and insecticides) that are used every day to kill, repel, and mitigate pests. We use them as an agricultural aid to increase both the quality and the quantity of our food. We spray them on our lawns and in our gardens in our quest for increased productivity, aesthetics, and manicured yards. We use them regularly to treat our homes for termites, cockroaches, ants, and other insects that invade our personal spaces. We use them to control or repel fleas, ticks, and mosquitoes that attack us and plague our pets. We use them to eliminate pests on stored products, in grain mills, and in packaged foods. We even use them in our deodorants, soaps, cleaning agents, waxes, and paints to curb the spread of bacteria and disease. Pesticides have made our lives safer and healthier, more productive and more comfortable. We depend on pesticides for every aspect of our lives.

Pesticides used within the home can yield positive health benefits. By spraying insecticide for cockroaches or setting traps baited with rodenticide for mice and rats, we can check the spread of disease throughout our households and workplaces. By bathing our pets with a flea and tick killer or by making them wear a flea collar we can reduce the chances of becoming infected with diseases like Lyme disease.

There are four main categories of pesticides:

1. ***Inorganic – of mineral origin; does not contain carbon.***
2. ***Organic – usually synthetic; contains carbon.***
3. ***Botanical – an organic pesticide derived or extracted directly from plants (not synthetic).***
4. ***Microbial – microorganisms or products produced by microorganisms that cause disease in pests.***

Adapted from Ware (1994)[1]

Health Benefits

Today we are increasingly confronted by the 'evils' of pesticides. However, while pesticides are often considered to adversely affect our health, they provide a great number of health benefits. Pesticides prevent a number of natural environmental toxins from being expressed in or on the foods we consume. A fungicide, for example, may leave negligible amounts of residue on produce while simultaneously preventing the fungal aflotoxins - naturally occurring fungal pests of a plant that pose a much greater health risk to the consumer - from forming.[2]

The effect of a natural environmental toxin is illustrated in the occurrence of the Salem Witch Trials. A fungus, ergot, contaminated rye, the staple of the Puritans. The symptoms of consuming the infected rye included hysteria and other severe mood alterations leading to the tragic and fear-dictated hangings of innocent 'witches.' Today, pesticides target these toxins that would otherwise infect our food supply.

Pesticides can also protect us from harm by reducing the toxins produced by plants themselves. Plants produce a number of their own natural toxins as a line of defense against organisms that prey upon them.[3] When insect, fungal, and weed pests inflict stress on a plant, these toxin levels increase for protection.[3] Natural toxins can be found in concentrations of up to 10,000 times that of synthetic chemicals used as pesticides[3] - levels that are sometimes quite hazardous to humans. With pesticide application, plant pests are managed and there is a corresponding reduction of stress and toxin levels found in the plants we consume, making them safer for the populace.

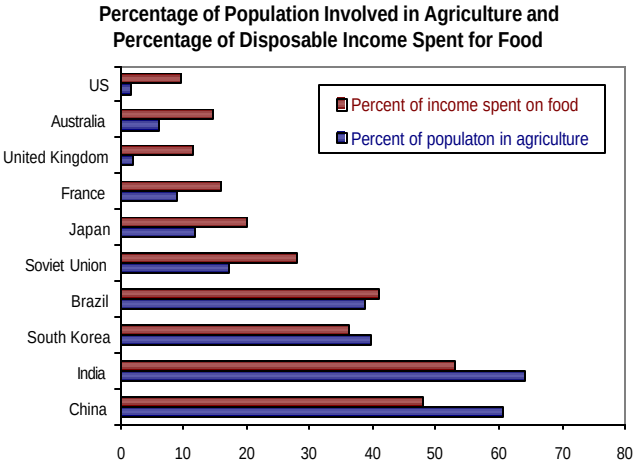
Consuming a raw mushroom poses a risk of cancer 100 – 1,000 times greater than risks from man-made pesticide residues.[3]

Consumers not only reap direct health benefits from pesticides, but cosmetic-health benefits as well. Pesticides leave our food with a cosmetic appearance – arguably, one that consumers cannot live without - while providing an essential service. Consumers are unable, generally, to purchase produce directly from growers. A substantial amount of time therefore must be devoted to the transportation of produce – to ship food from producers to retail outlets instate, nationally, and globally. During transport, storage, and retail distribution, our future meals are safeguarded by the use of pesticides that are applied in the field and in storage. As a result, we are protected from poor quality, rot, and decay in the food supply, which would be unappealing to most consumers and potentially yield negative health effects.

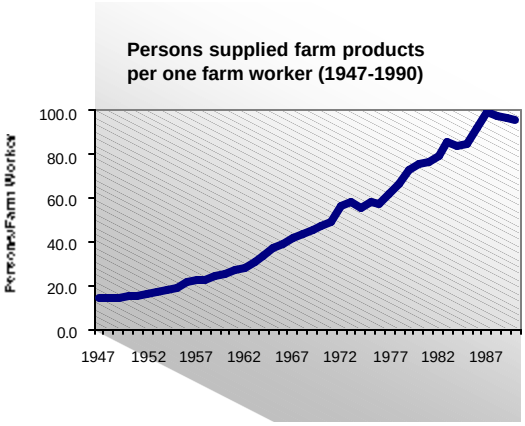
Economic Benefits

The benefits of pesticides are not limited to issues of health; there are a variety of economic rewards to pesticide use. On an individual or family level, the cost of health care is reduced because the food supply is clean and complications like asthma, allergy, and the 'plague' - transmitted or induced by insects and rodents around the home - have been curtailed. Some proponents of pesticides might even maintain that a reduction of beneficial chemical pesticides would result in a drastic decline in public health that would greatly offset any negative health side effects of pesticides. Such individuals might continue to insist that by raising the health risks to humans through curbing the use of pesticides, there would be a substantial increase in the cost of individual health care.

Pesticides are the first line of defense in pest control when human lives are threatened (i.e., insect vectors of disease) or when agricultural commodity losses are believed to be economical.[1] Pesticides are the only line of defense in many cases. In 1990, it was estimated that $30 billion in damage to agricultural commodities was caused by insects, weeds, and diseases on an annual basis.[1]



Farmers use pesticides to increase productivity, thereby creating lower prices to the benefit of consumers of food and fiber products.[1] Compared to other countries, U.S. consumers spend the least percentage of their income on food. In addition, agricultural productivity has lead to larger farms with fewer inputs. In the late 1700's, each farmer in the U.S. produced enough commodities for 3 people. This number has grown to roughly 100 people supported per farm worker in 1990.[1]



Today, the world population exceeds 7 billion. Of those 7 billion individuals, 56% of the total population and 79% of the population of developing nations are undernourished.[1] Future world population figures are forecasted to grow to 12 billion people by 2040 resulting in a greater pressure to increase food, clothing, housing, and infrastructure development.[1] Pesticides allow for this production of an plentiful, accessible, and economical food supply by boosting crop yields, by reducing production costs and consumer prices,[2,4] and by protecting human health, homes, and structures.

Pesticide Benefits

Pesticides have been the 'silver bullets' we use to mend the ills of the world. *We have been habituated to and dependent on pesticides to support a multitude of aspects of society's infrastructure. Pesticides are essential for feeding, clothing, and protecting people, plants, and animals, and we need them to sustain the quality of life to which we have become accustomed.*

Chapter 2

Pesticide Legislation

Past, Present, and Future

Pesticide legislation was initially enacted to protect farmers from 'snake oil' salesmen and charlatans in the early 1900's. Since, pesticide regulatory efforts had become somewhat variable. The passage of the Food Quality Protection Act (FQPA) on August 6, 1996 changed the landscape of pesticides forever. As a result, regulators were provided with an increased incentive to streamline pesticide use and develop alternatives to pesticides that were once praised for their effectiveness and universality: the organophosphates, the carbamates, and methyl bromide. In the future, it is likely that such incentives to reduce the use of pesticides will expand to other categories of pesticides. The development of alternatives to triazine herbicides, ethylene bis-dithiocarbamate (EBDC) fungicides, and ecosystem-damaging synthetic pyrethroids - currently hailed as essential pesticides and utilized extensively - will become critical. As a society, we are becoming entrained to a progressive regulatory treadmill with a destination of 'natural,' 'environmentally friendly,' and 'human-safe' pesticides for the 21st century.

Types of Pesticide and How They Work

Pesticide	Mode of Action
Protectant	Prevents pest from being established
Sterilant	Inhibits reproduction or eliminates pest from specific area
Selective	Effect against one type of organism
Nonselective	Affects many organisms
Broad - spectrum	Controls a wide range of pests
Contact	Affects pests by coming into contact
Systemic	Absorbed and move through pest
Persistent	Remains active over time
Nonpersistent	Affects pests right away then breaks down rapidly

Adapted from Ware (1994)[1]

Factors contributing to Food Drug Protection Act (FQPA)

- ***The Delaney Paradox.*** *The Delaney Clause of the Food Additives Amendment to FFDCA (1958) stipulates a zero tolerance for potential carcinogens in processed foods. This created a unique paradox where a pesticide that could not occur in any amount in processed foods could be used on the raw commodity. In addition, pesticide detection has improved greatly over the years.*[5]
- ***Montreal Protocol: Ban Methyl Bromide.*** *In 1992, the Montreal Protocol, administered by the United Nations Environment Programme, established methyl bromide as an ozone depleting substance and achieved agreement among many nations around the world to phase out the use of methyl bromide. In the U.S., these provisions are tied to the Clean Air Act of 1990.*[6]
- ***Children ? Little Adults.*** *A 1993 report by the National Academy of Sciences found that food tolerances for pesticides should be lowered to account for differences in sensitivity of children compared to adults.*[7]
- **Our Stolen Future** ***and Endocrine Disruption.*** *The 1996 book* Our Stolen Future *chronicled pesticide-related human health problems and the reproductive effects on wild and domestic animals as a result of endocrine disruptors – chemicals that mimic and/or block hormones.* [7]

Pesticide Policy Time Line

1906 Federal Food Drug and Cosmetic Act (FFDCA)

1938 Miller Amendment to FFDCA
Sets residue tolerances on pesticides in food products.

1947 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
Requires registration and proper labeling of pesticides including herbicides; administered under Pesticide Regulation Division of USDA.

1958 Food Additives Amendment to FFDCA
All food additives included under Miller Amendment; inclusion of Delaney Clause.

1959 FIFRA Amended
Inclusion of nematicides, plant regulators, defoliants, and desiccants as pesticides.

1964 FIFRA Amended
Labels must include registration numbers, caution words, and "Keep out of reach of children."

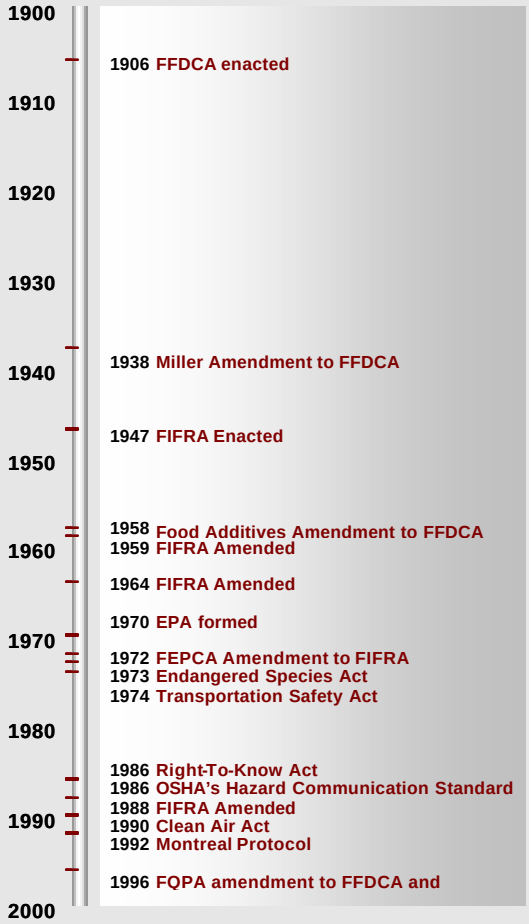
1970 EPA Formed
Administers FIFRA, has authority to establish new pesticide tolerances. FDA continues to enforce tolerances.

1972 Federal Environmental Pesticide Control Act (FEPCA) Amendment to FIFRA
Enforces pesticide use consistent with label, requires pesticides classified as general- and restricted-use, in-state licensing of restricted-use applicators, in-state registration and inspection of pesticide manufactures, registration process to include evidence that pesticide effectively controls pest on label, will not injure humans, crops, livestock, wildlife, or environment, and will not result in illegal residues in food or feed.

1973 Endangered Species Act
Requires that all federal agencies, including USDA, FDA, and EPA not jeopardize endangered or threatened species and their habitats.

1974 Transportation Safety Act
Authorizes US Department of Transportation to declare, issue, and enforce hazardous materials regulations for all modes of transportation.

Pesticide Policy at a Glance



1986 Right-To-Know Act
Requires employees be informed of hazardous material presence and emergency planning procedures.

1986 Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard
Material Safety Data Sheets (MSDS) must be available where toxic chemicals are handled and processed.

1988 FIFRA Amended
Increases EPA involvement in registrations, fees, expediting registration applications, disposal, transportation, and indemnification of cancelled pesticides.

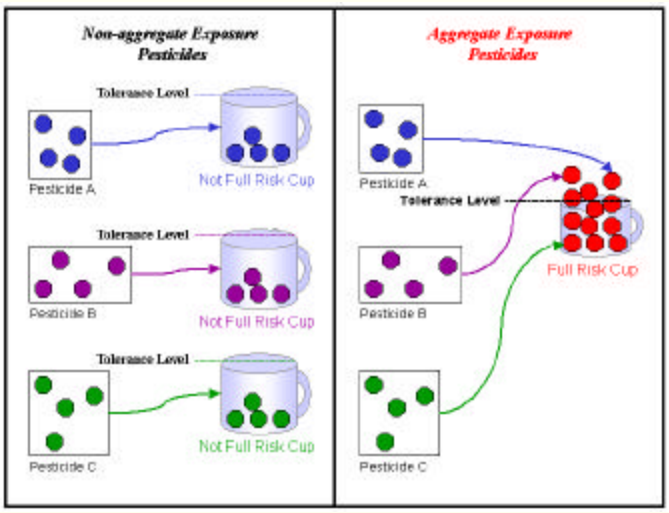
1990 Clean Air Act
Sets ozone depletion potential threshold, above which substances will be cancelled.

1992 Montreal Protocol
Lists methyl bromide with an ozone depletion potential greater than the threshold for cancellation.

1996 Food Quality Protection Act (FQPA) amendment to FFDCA and FIFRA
Sets a tougher, single, health-based standard for assessing risk of residues. Standard considers aggregate exposure from dietary and non-occupational sources. Additional safety factors for infants and children and for uncertainty in data. Requires endocrine disruption screening. Includes consumer right-to-know about residues on food.

Federal Food Drug and Cosmetic Act (FFDCA) Provision[8]

- *The Delaney Paradox is resolved to provide that tolerances in both raw and processed foods will be set to, and held, under the same provisions.*
- *A ten-fold safety factor will be used to protect infants and children in addition to other safety factors currently in practice.*
- *Food consumption, pesticide residues, and pesticide use data are required.*
- *EPA will set tolerances based on aggregate exposures to dietary and non-food residues. A risk cup is filled with aggregate exposures of pesticides with common mechanisms of toxicity.*
- *All existing tolerances will be reviewed within the next 10 years. Tolerances that do not meet the safety standard may remain in effect if the pesticide is beneficial to human health.*
- *Any compound that is an endocrine disruptor will not be registered.*

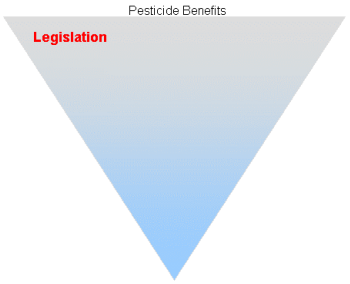


- *Consumer right-to-know brochures about pesticide residues on food will be made available.*

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Provisions[8]

- *EPA can conduct emergency suspensions of pesticides.*
- *All pesticides will be reregistered.*
- *Minor use pesticides will have registration incentives.*
- *Reduced-risk pesticides will be fast-tracked when registered.*
- *Antimicrobials are no longer held to the provision of FIFRA.*
- *Applicator training will mandated for a larger segment of commercial applicators.*

Despite the benefits of pesticides and the measures taken to reduce their risks, the use of pesticides remains a complex and controversial issue. There continue to be volatile and conflicting perspectives held by many different sectors of society: government, science, business, and public. Some of the concerns voiced by the various social groups that have opined on the issue include questions regarding the impacts of pesticides on human health, the effects of residues in the food supply, the results of pesticide sprays on non-target organisms and biodiversity, the incidences of pesticide resistance, and the impacts on both national and global economies.



Pesticides: Are our miracle cures falling from grace? *The globalization, 'greening,' and 'consumerism' of society have driven the implementation of regulations on pesticides, causing our 'silver bullets' to come under close scrutiny. Conflicting perspectives and confusion incited by these regulatory efforts and evaluation processes have diminished our hopes of continuing to use pesticides as 'silver bullets' in the war on pests, and are leading to a fast-paced transition away from pesticides toward alternatives.*

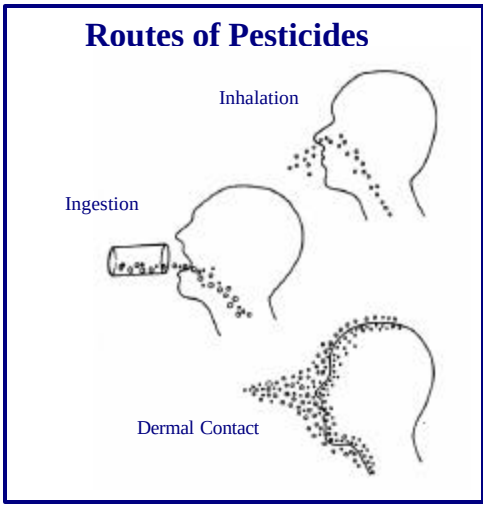
Chapter 3

Human Health and Exposure

Modes of Exposure

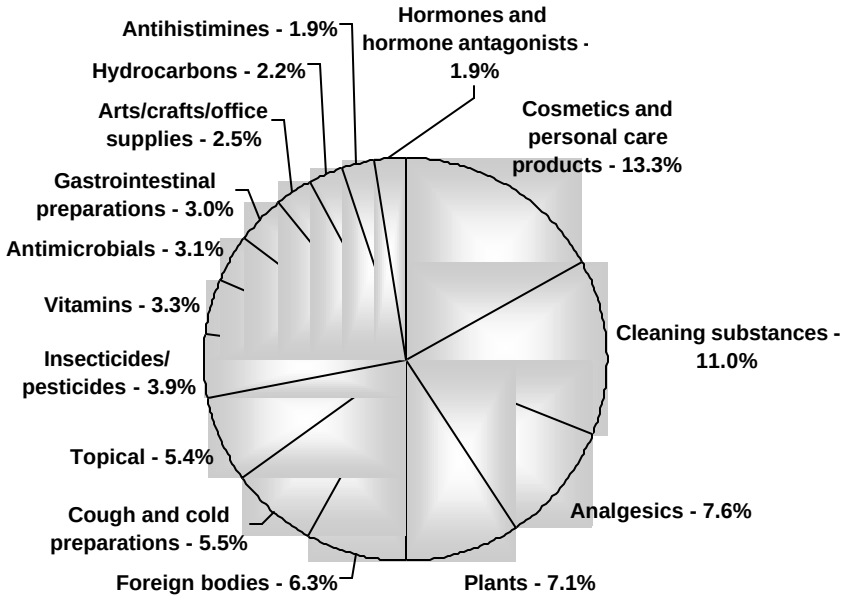
One of the greatest concerns about the use of pesticides is the effect that they have on our health. Virtually all arguments against pesticides stem from this aspect of concern: government regulations are enacted to protect those most vulnerable, non-governmental organizations (NGOs) exploit social fears to incite actions against pesticide use, and businesses enlist the aid of science to determine the true health effects in an attempt to assuage the fears of the public.

We are exposed to pesticides through a variety of routes and under a multitude of circumstances. Pesticides can be absorbed through the skin, the eyes, the digestive system, the lungs, and the placenta. Individuals may be exposed at work or at home, from eating a meal or from playing in the yard. Infants may even be at risk of exposure through their mother's milk. We are all vulnerable to exposure via our clothing, bedding, pets, paints, soaps, and powders, through the air, and from countless other environments and substances.



Adapted from[19]

Most Frequent Pesticide Exposures by Infants



Adapted from Lizovitz et al. (1998)[9]

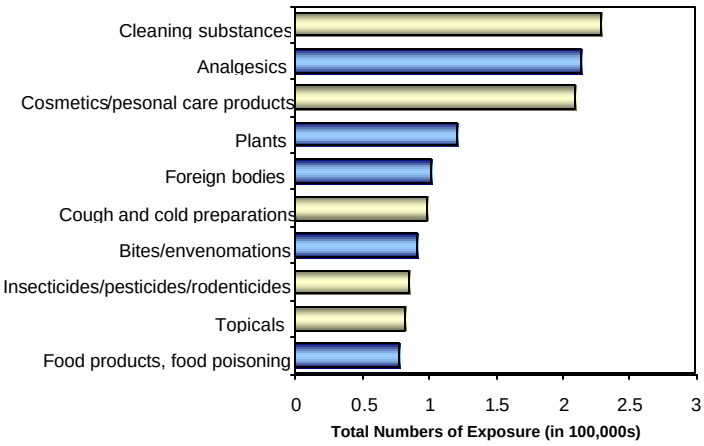
The amount of pesticide exposure and the subsequent health hazards depend upon the setting in which one is exposed. A child playing on a kitchen floor that has recently been mopped with a chemical cleaning agent is exposed to a significantly different amount than an individual who is mixing a pesticide to be sprayed in an orchard. The concentration, type, and usage of a pesticide are also important determinants of personal exposure. A pesticide applicator, for example, may be exposed to pounds of concentrated pesticide while a person eating an apple may be in contact with less than one part per billion.

Health Effects and Symptoms of Exposure

One of the greatest dangers of pesticides is that evidence of exposure may become masked because of similarities to other ailments.[10] Pesticides may have many systemic effects within the human body. The most common symptoms imitate heat exhaustion, a common effect seen in agriculture or other settings that involve being outdoors or in close proximity to treated materials. Other symptoms of pesticide exposure mimic the common cold, which may be dismissed by relatives, friends, and coworkers as an insignificant occurrence rather than evidence of exposure.[10] Symptoms manifest themselves on the skin (rash, abrasion), in the eyes (tears), in the heart (bradycardia), in the lungs (dyspnea), or in the digestive system (nausea, vomiting, diarrhea, abdominal pain, salivation).[11] Many of these symptoms resemble those of other health complications and therefore it is difficult to identify if one is ill as a result of exposure.

Health effects of pesticides are not limited to body organs. Neurological effects of acute exposures may include headaches, paresthesia (numbness, pins-and-needles), depression, muscle twitching, and incoordination. Chronic exposure may lead to persistent headaches, blurred vision, unusual fatigue or muscle weakness, and problems with mental functions (memory, concentration, depression, or irritability).[12]

Top Ten Most Frequently Involved Subtances in Human Exposure



Adapted from Lizovitz, et al. (1998)[13]

More recently, it has been shown that the endocrine and the reproductive systems of mammals (including humans), birds, reptiles, amphibians, fish, and arthropods may be affected through pesticide exposure as well. Some of these health consequences include an increase of drug metabolizing enzymes in the liver or related tissues and a decrease of enzymes essential for neurological and reproductive functioning, possibly resulting in infertility. Exposure to estrogen mimicking pesticides during the development of the reproductive system may affect the later reproductive health of an individual. In the Food Quality Protection Act (FQPA), Congress mandated that the EPA identify chemicals that might interact with the human endocrine system and confirm and characterize the effects of these chemicals on the endocrine system.[14] As a result, the EPA must develop high through-put tests (making it very costly for registrants to comply) to detect endocrine disruption.[14] These new tests will include tiered in vitro, and subsequent in vivo, studies of hormone output and receptor interactions. To compound the effects of this mandate, endocrine disruption has become an issue of controversy because there has been a lack of reproducible data – the very essence of scientific information – and withdrawn evidence.

Concerning Children

Stimulated by FQPA legislation, the EPA has experienced heightened concern about the significance of pesticide effects on the development of children, from conception to early childhood. Children may be exposed to larger and more variable doses of pesticides in the home and in school environments than adults.[15] They may also be more susceptible to pesticides during a succession of critical developmental stages because their physiology is less robust at detoxifying or excreting pesticides that enter their systems.[16] Because of these potential threats to our children, pesticides have become increasingly and more strenuously regulated to reduce the incidences of harm.

Cancer Issues

According to the American Cancer Society, there have been 15 million new cases of cancer since 1990.[17] Further justifications for the strengthening of pesticide regulation are these increasing numbers of cancer cases and the fact that, at certain doses, pesticides have the potential to induce carcinogenic effects in the body. School teachers have cited strange allergies, skin rashes, and cases of breast cancer possibly resulting from pesticide exposure. Children may have an increased risk of cancer because their bodies are already in a period of rapid growth and change.[18] Those children who are regularly exposed to pesticides may be 3-7 times more likely to develop Non-Hodgkin's lymphoma (NHL). [18] Farm workers appear to have higher incidences of prostate cancer than men in other occupations. The suspected carcinogenic effects of pesticides have resulted in de facto changes in cancer policies. As a result, many chemicals are moved from lower risk categories to higher risk categories, making it more costly and more difficult to use certain pesticides that were once considered virtually harmless.

Worker Exposure

Since there are exposure risks from pesticides that are unique to those who work directly with them, either by synthesizing, applying, or harvesting, worker protection from exposure is also carefully regulated. Two U.S. agencies share the responsibility for protecting those who work directly with pesticides: the Environmental Protection Agency (EPA) and the United States Department of Agriculture (USDA). It is important to examine the roles of these two regulatory bodies to understand how they shape the landscape of pesticide exposure.

The EPA is mainly responsible for the development of safety rules and regulations concerning pesticide application and worker protection standards. The EPA requires the use of steps to reduce worker injury and exposure, and also regulates pesticides by requiring them to be registered before marketing. Standards set by the EPA may be enhanced and pesticide use may be further restricted by individual state governments. Thus, pesticide regulations may vary widely from state to state.

EPA Requirements for the Reduction of Worker Injury and Exposure[19]

1. *Information about the pesticide and its effects must be displayed.*
2. *Applicators must be trained in pesticide use and safety procedures.*
3. *Decontamination sites must be made available.*
4. *Workers must be notified of application and re-entry times, and of the location of pesticide information displays and decontamination sites.*
5. *All protective equipment must be supplied and used.*

Even with all of the EPA regulations on pesticide application, worker exposure to pesticides still occurs. For example, in agriculture, crop conditions, weather, and other factors may force workers to enter pesticide treated fields too soon after sprays - despite regulations - and workers in adjacent fields can be exposed to chemicals as a result of wind patterns. To combat these types of exposures, those who work with pesticides may only do so after certification. The administration and training of individuals who work with pesticides are undertaken by the USDA. Applicators are trained in the techniques of pesticide handling and in the safety procedures required by the EPA. The USDA also imposes severe penalties on

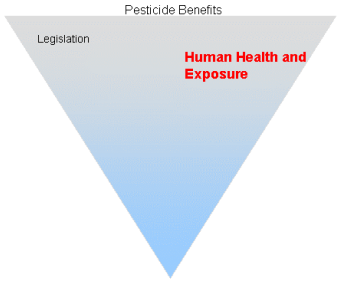
applicators if they fail to follow guidelines and if they misuse pesticides. Civil penalties for pesticide misuse incur a $1,000 - $5,000 fine, while criminal penalties result in up to $25,000 in fines and 30 days in prison.[19]

The EPA and the USDA regulations are specifically designed to protect workers from hazardous chemicals exposure. Pesticide applicators have gone an additional step further to ensure the enforcement of regulations by forming unions. One example, again from agriculture, is the United Farm Workers (UFW). This is an organization that endeavors to provide safer working conditions for both the pesticide applicator and the food harvesters, who are often low-income, uneducated laborers or migrants. Organizations like the UFW are often involved in movements and boycotts in an attempt to prevent hazardous chemicals from being used in the workplace. Unfortunately, while incidents of exposure are serious and should be examined and rectified, it is not uncommon for claims against the safety of a chemical to be false alarms. As a result, public controversies are incited and valuable time, labor, and money are drained away from resources that were intended to develop pesticide alternatives.

The United Farm Workers (UFW) worked toward obtaining a federal ban on five pesticides that were perceived to be a hazard to their members: grape workers and grape consumers.[3] Because questions were raised and the public was impelled to learn if they were at risk, an extensive and costly study of the five pesticides was conducted. All of the chemicals in question were found to be within legal limits As a result of the UFW pressure, the EPA put captan under special review because of its classification as a potential carcinogen.[3]

Pesticide in Question	Study Results
Dinoseb	Already banned from use on grapes in 1986
Methyl bromide	A soil fumigant – leaves no exposure residues
Parathion	Detected at 1/5 the legal limit set by the EPA
Mevinphos	Not detected
Captan	A potential carcinogen – found in only 10% of samples at levels 10% below EPA tolerances

Adapted from Winters (1989)[3]



Silent and Deadly: Are Pesticides Killing Us? *With prevalence in virtually every human environ and with symptoms that mimic common ailments, pesticides seem to be unknowingly and dangerously everywhere. Concern over environmental and worker exposures has lead to a heightened public concern and an erosion of society's confidence in the safety of pesticides.*

Chapter 4

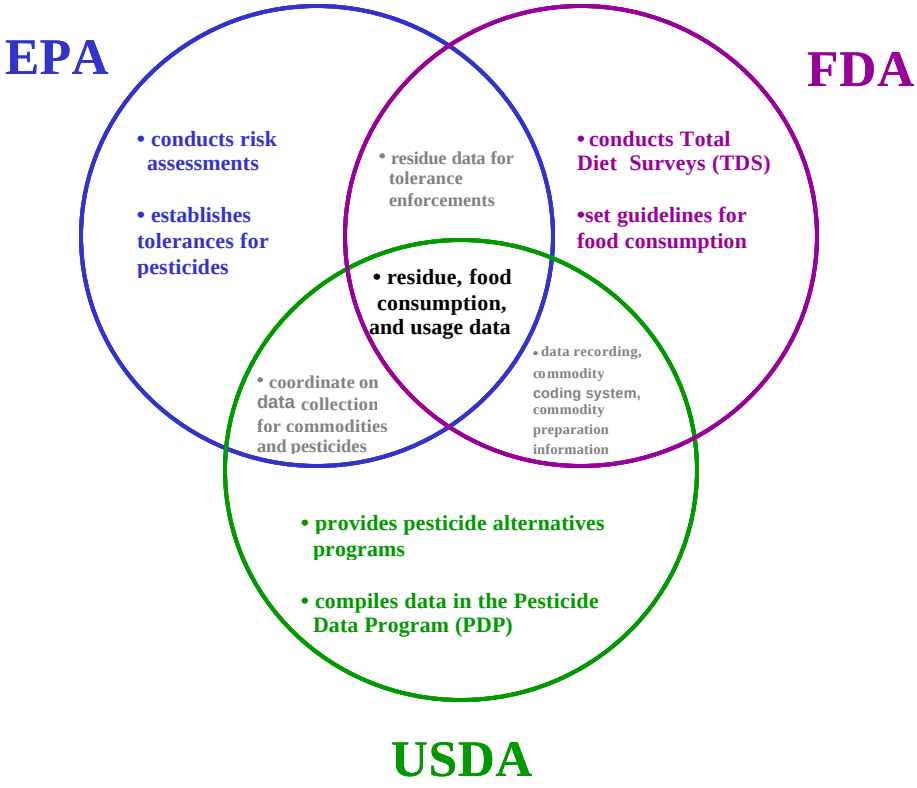
Pesticide Safety

The Role of the Government

Earlier we discussed the role of the Environmental Protection Agency and the United States Department of Agriculture in regards to the exposure of workers to pesticides. However, the government has a much broader involvement in the realm of pesticide use: collecting data concerning food residues, developing pesticide alternatives, setting safety and application guidelines, and performing a multitude of studies to determine the health risk of pesticides. Government involvement is delegated to three groups: the Environmental Protection Agency (EPA), the United Stated Department of Agriculture (USDA), and the Food and Drug Administration (FDA). Together these agencies interact in a system of checks and balances to provide a safe and accurate understanding of the impact of pesticides in our lives.

The United States Department of Agriculture (USDA) collects and provides to other government agencies and the public "data on dietary exposure to pesticides, food consumption, and pesticide usage."[20] These data are necessary for conducting dietary risk assessments and for evaluating pesticide tolerances. The department compiles the information into a database known as the Pesticide Data Program (PDP) which can be found on their website (http://www.ams.usda.gov/science/pdp/index.htm).[20] In addition, the USDA collects agricultural chemical usage and pesticide residue data, also found in the PDP. Food consumption, residue, and usage data are then given to the EPA and the FDA. The USDA is also involved with the development of pesticide alternatives, which are increasing in demand in today's new 'green' society.

The Interacting Roles of Pesticide Regulation



The Environmental Protection Agency (EPA) communicates with the USDA to obtain accurate pesticide use data for commodities in order to monitor the flow of pesticide utilization. Pesticide usage, pesticide exposure, and human and animal consumption data are collected from the USDA and the FDA. These data are then analyzed for EPA risk assessments that ultimately lead to the establishment of legal residue tolerances. The EPA also regulates pesticide usage by setting procedural and safety guidelines for pesticide application.

The Food and Drug Administration (FDA) shares pesticide data recording, commodity coding, and commodity preparation information with the USDA. The FDA collects residue data on domestic and imported foods to enforce pesticide tolerances and food guidelines established by the EPA. The FDA also surveys total diet information of various population demographics and sets administrative guidelines for food consumption.

The FDA's Market Basket Survey can detect up to 200 different chemicals. The FDA also analyses residues through its Total Diet Study, which monitors residues in foods purchased in retail stores. The foods are then prepared for consumption, and residues are detected at the time the food is "as close as possible" to consumption. In the 1990 Total Diet Survey only 51 of the 200 chemicals were found.[21]

Residue Tolerances: Complications and Misconceptions

The EPA is responsible for the establishment of tolerance levels for pesticide residues in food items. These tolerances are often confused as safety standards,[21] but they are actually limits that are intended to indicate the misuse of, and accidental contamination of, pesticides. Actual residue levels are usually much lower than the tolerances set by the EPA, and residues that violate these tolerances are rarely of any health significance.[21]

A surprising amount of public concern, mostly unfounded, revolves around the significance of residue tolerance violations. When residues exceed tolerances (illegal residues), it may not mean that these residues are even remotely close to levels dangerous to humans and/or animals, yet unease over pesticide use is still rampant. The majority of illegal residues from food occur when an otherwise legal residue is found on a crop, food, or product on which it is not registered. [21] In fact, approximately 69% of residue violations are on commodities where tolerances have not been established.[21] Other misconceptions involve the overstatement of residue levels. Often the number of pesticides registered for use on a product is extensive, while the number of pesticides actually used and the subsequent residues are quite limited. Many interest groups in society take advantage of these misconceptions concerning residues - overstating the risk of residues by citing statistics based on the assumption of the presence of maximum residues from every legal registered pesticide for a commodity.[21]

Other controversies concerning residues surround the EPA's determination of residue tolerances. Is every individual protected under the blanket of tolerances set by the EPA? Are limits on pesticide residues unnecessarily restrictive? Are the calculations used to establish residues sound? The EPA is pressured to accommodate the demands implied by these questions. They must make sure that the most sensitive and 'at risk' individual is unharmed even in worst-case scenarios of pesticide use. Therefore, the EPA imposes several 'safety factors' to further lower legal residue limits to insure that all individuals are adequately protected. Many different sects of society contest the EPA risk assessment guidelines as "too restrictive" (agriculture and those who rely on pesticides economically) or "not restrictive enough" (the public and non-government organizations). This interplay of interest groups makes pesticide policy highly political and controversial.

The calculation of human pesticide exposure from residues is the product of the amount of food consumed and the concentration of chemicals in various foodstuffs.[2] The estimation of these variables may require many assumptions and involve many uncertainties because of inconsistencies in data reporting and acquisition, limits of technology in data analysis, and possible unknown compounding or carcinogenic effects of the chemicals.

Human Pesticide Exposure =

Food Consumed x Chemical Concentration in Food

In addition to questions surrounding the accuracy of exposure calculations, there is uncertainty in determining the risk from such exposures. Many of the ways in which risks are determined are contested. For example, despite known critical physiological differences between humans and other animals, animals are frequently used to predict the effects of pesticides on humans.[21] Obviously the use of 'human subjects' in pesticide exposure studies is unethical. However, many could argue that risk estimations are grossly inaccurate because of the distinct variances in human and animal physiologies. Another point of contention involves the extrapolation of the effects of high doses of pesticides to low dose effects.[21] Many chemicals have carcinogenic effects at high enough doses. This does not mean, though it is often thought to mean, that the chemical is cancer causing at the lower dosages. Salt, for instance, is not harmful (in terms of carcinogenicity) in the doses we use to season our food, but if we consumed mass quantities of it, it could be quite harmful.

There are other questions regarding the hazard assumptions of carcinogenic pesticides. While non-carcinogens typically exhibit toxicity thresholds, carcinogens are believed to have no lower effect threshold.[2] The absence of a lower threshold makes it difficult to determine what levels are safe and what are not. As a result, carcinogens may be considered hazardous at any amount and those pesticides that are considered a potential carcinogen may have extensive, possibly unnecessary, regulatory restrictions. Even the processes used to determine carcinogenicity are controversial. Animals used to determine carcinogenicity are often from a strain selected to yield tumors much more frequently, and when these strains are found to have even small benign tumors, the EPA may consider a compound carcinogenic.[2]

If a pesticide has been found to cause cancer in laboratory animals, it is often assumed that the same effect will be true for humans. The pesticide effects become translated as human effects, despite organismal differences.

Technological limitations are another hurdle in determining exposure to pesticide residues. It is likely that even in today's 'high-tech' society we don't have the means to adequately detect all of the pesticides used – especially natural or organic pesticides. In 1986, for example, several of the pesticides with the greatest potential health consequences were not detected in the FDA's five multiresidue screens.[21] While the margin of technological inadequacy has undoubtedly improved over time, there is still a significant likelihood of oversight in the detection of potentially dangerous pesticides on food and in our environments.

Chemophobia

The uncertainties involved in the calculation of tolerances for pesticide residues have resulted in varying interpretations among interest groups about the actual amount of pesticides residues detected. These interpretations of the data collected and analyzed on pesticides and the presentation of these data to the public significantly determine the fate of a pesticide. Many organizations place a spin on and/or exaggerate the governmental pesticide information in an attempt to influence the public against the use of pesticides. For example, if you take a look at the graphic that compares the FDA figures for the Acceptable Daily Intake of certain chemicals with those of the Natural Resources Defense Council (NRDC), you will notice that there is a significant difference in the reported percentages. When

The calculated exposure of a specific pesticide is typically less than 1% of the Acceptable Daily Intake (ADI), as estimated by the World Health Organization.[22]

non-governmental organizations (NGOs) like the NRDC present inflammatory data that is so dissimilar from those published by the USDA, the FDA, or the EPA, the public may feel that they have 'been had' by the government. Such variances in reports spark public distrust of the government and of the validity of the scientific data addressing residues.

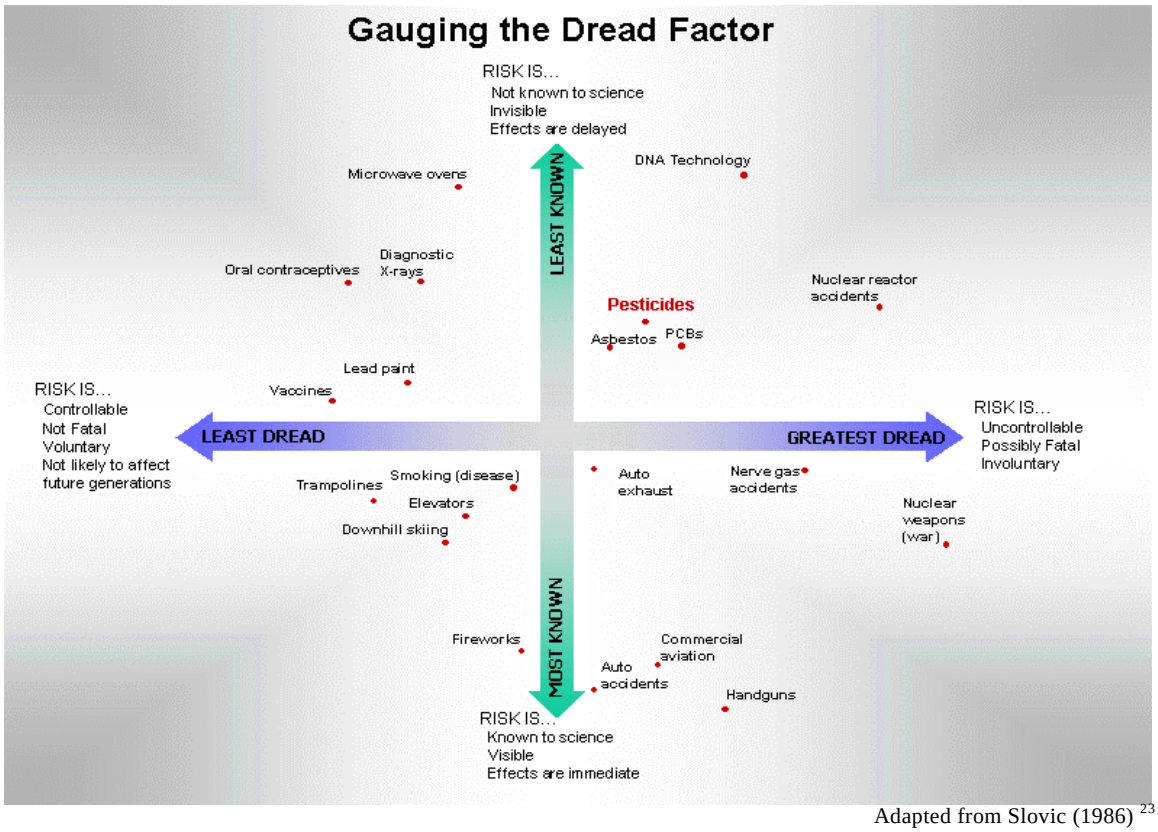
A Comparison of the Disparity in Reported Dietary Exposures between a NGO and the FDA [21]

	Environmental Protection Agency (EPA) Acceptable Daily Intake (ADI) (%)	
Pesticide	**National Resources Defense Council (NRDC)**	**Food and Drug Administration (FDA)**
Acephate	7 – 206	1.2
Azinphos methyl	5 – 96	0.4
Diazinon	22 – 711	5.5
Methamidaphos	180 – 880	22.0
Methyl parathion	20 – 492	0.04
Monocrotophos	6 – 9200	0.2
Omethoate	20 – 370	1.3
Parathion	24 - 312	0.9
Total	**284 – 12,267**	**31.54**

The distrust of the public may also stem from fear and frustration of risk information that may be confusing and not adequately explained.[21] In addition, the generally naïve views held by the public about the risk of pesticides may easily become manipulated by organizations that target the potential risks (versus actual risks) of pesticides as detrimental to human health.

NGOs and other 'public interest' groups not only take advantage of public confusion and fear of risk assessment information. They also negatively caricature pesticides as dangerous and seek to appeal to certain instinctual emotions of society. For example, certain groups like children are targeted because risks to their safety incite parents to work for their protection. These perceived risks of pesticides may be real or imagined, but they provide fodder for memberships, donations, and media events for some 'watch dog' groups.

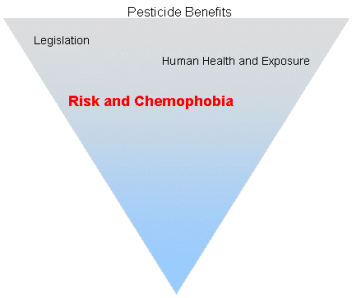
> ***"…between 5,500 and 6,200 of the current population of preschoolers may eventually get cancer solely as a result of their exposure before six years of age to eight pesticides or metabolites commonly found in fruits and vegetables…"***
> ***–NRDC (1989)*** [21]



Adapted from Slovic (1986) [23]

It is estimated that up to 80% of U.S. shoppers consider pesticide residues to be an important issue.[21]

Society's concern about pesticides safety is primarily instigated by the popularization of these issues by groups like the NRDC rather than solid scientific literature.[16] Perhaps because of fear that scientists are in cahoots with pesticide companies for monetary gain or because of frustration at the incomprehensibility of risk assessment information, the public pays less attention to the hazards as reported[2] by scientists and government agencies. Instead, we tend to believe the simplified versions of truths and the inflated numbers of exposures that have been digested, regurgitated, and fed to us by NGOs. Similarly, those in science tend to pay scant attention to public outrage and dismiss their indignation because they feel it is unfounded.[2] The disparity of views regarding the dangers of pesticides and their residues results in a dissonance between scientists and society at large. As a result, society is moving toward pesticide use minimization and an increased development of natural alternatives to pesticides.



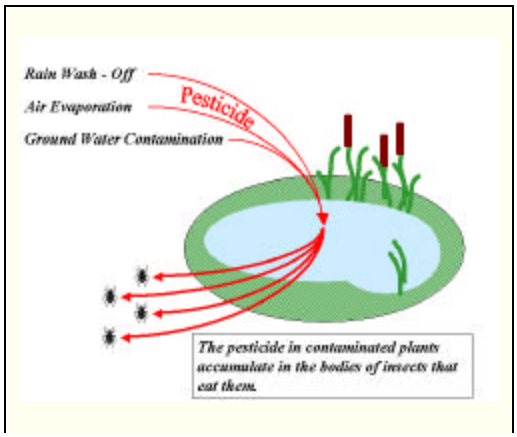
Pesticides the Terrible: Perception is Reality. *Governmental agencies and research organizations strive to provide the most accurate information on pesticide risk while endeavoring to protect every individual from harm. Unfortunately, misrepresentations of scientific information continue to fuel the public's distrust of pesticides, pesticide producers, and the scientific community. In the end, society will demand nothing less than stricter protection from the tyranny of pesticide use.*

Chapter 5

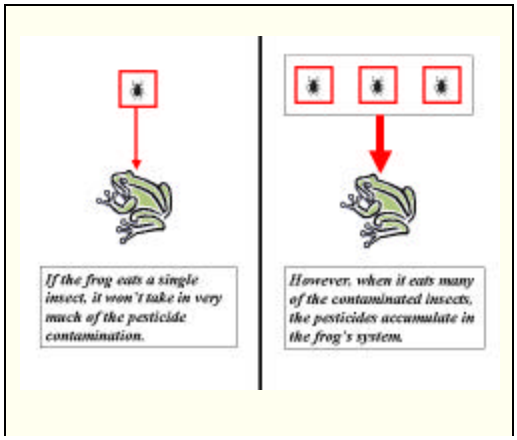
Non-target Effects of Pesticides

Reduction of Biodiversity

The effects of pesticides on our environment tend to carry less weight among the public because there are fewer overt human health risks. However, pesticides in the environment are still of significant concern and they can impact both the environment and its organisms in a multitude of ways. Pesticides influence our lives directly through the killing of pests and indirectly through the contamination of ecosystems and populations of microorganisms, plants, and animals. Chemicals can escape into the environment from many sources: agricultural lands, yards, homes, food storage facilities – essentially, any area where pesticides have been used. They contaminate the environment by evaporation into the air, by leaching into the groundwater, by run-off into rivers and lakes, by wash-off from the rain, and by countless other pathways.

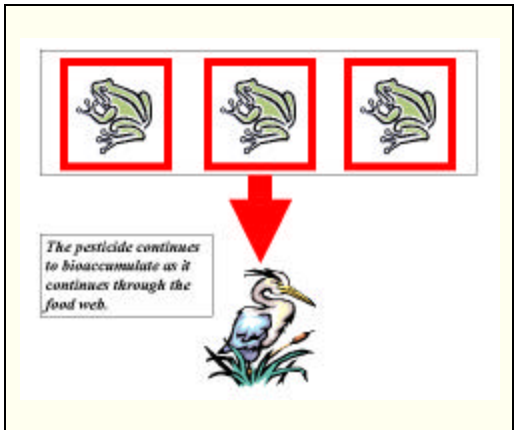


A pesticide rarely remains contained within the ecosystem it initially contaminates. Once a pesticide has entered an ecosystem, it continues to flow into surrounding ecosystems. For example, a pesticide may originally be introduced into the environment through groundwater. Through biotic and abiotic pathways it may be transferred to other strata like the land or the air. Eventually, the pesticide effects are expressed in ecosystems around the globe, and the planet's biodiversity becomes altered.



Biodiversity is the abounding variety of life forms found on our planet: plants, animals, insects, microorganisms, and genetic material of a specific ecosystem.

Pesticides not only invade the land, water, and air - they are taken up by organisms within these environments via food systems. The pesticides can 'bioaccumulate,' or build up, in organisms throughout the food webs of an ecosystem. As accumulation increases, so do the adverse effects on the various species, and ultimately the natural balance of the ecosystem is disrupted.

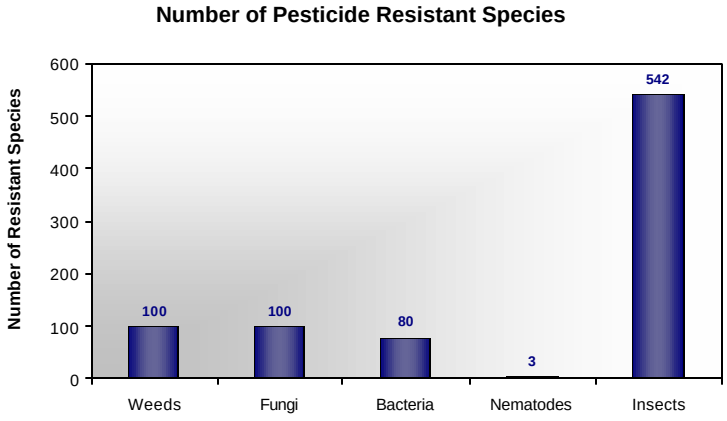


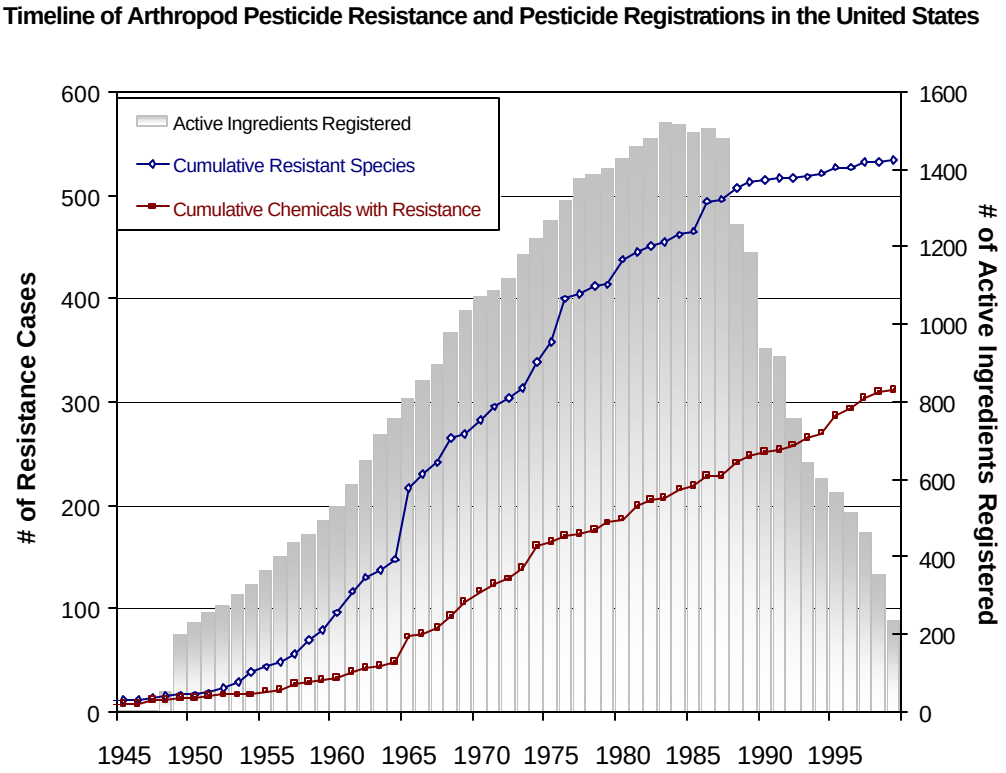
Similarly, the biodiversity of human ecosystems are disrupted. For example, in a farm ecosystem - an agro ecosystem - the crops, weeds, insects, worms, fungi, and bacteria become affected by the pesticides that enter the ecosystem. Healthy agro ecosystems help to promote sustainable agricultural systems by reaping more long-term benefits that sustain soil, farms, public lands, and watershed conditions. It becomes critical, therefore, to maintain such life ecosystems for the growing population

and for future generations. Pesticides may reduce the sustainability of our life systems by lowering or eliminating populations of many important organisms in the soil that recycle nutrients. They may kill the natural enemies of key pest species and other beneficial organisms. Plant and animal characteristics that may provide vital solutions to eliminating diseases like cancer may be in jeopardy because pesticides affect their requirements for survival. The resulting reduction of biodiversity may ultimately threaten the long-term survival of humans as a species by reducing food supply and increasing disease.

Resistance to Pesticides

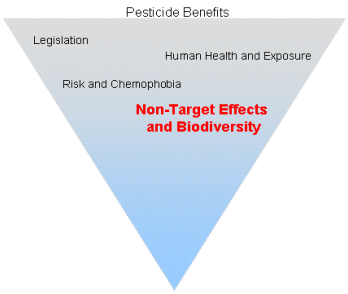
While the diversity of our biosphere is being altered through pesticide use, the chemicals themselves are becoming less and less effective at controlling the pests we revile. Pesticide resistance was first documented in insects in 1914.[24] Since, many new insecticide resistance cases have been reported. However, recently the rate in accumulation of resistance cases has declined, most likely the result of a concurrent reduction in the rate of introduced pesticide compounds (a result of increased legislative regulations).





Pesticide resistance is the result of pesticide selection - the microevolutionary process of genetic adaptation through the selection of biocides. The consequence of this selection and genetic adaptation is the failure of the pesticide to control the pest. In essence, the pesticides kill the weak and leave the strong. The strong individuals then pass the characteristics that allow them to survive on to their offspring. Pests can even develop resistance to a chemical to which they have not had prior exposure. This cross-resistance occurs when a pest has already developed resistance to a structurally similar chemical.

The trend of pesticide resistance has recently captured increased public attention with the use of pesticides in the form of antibiotics. Hospitals have increasingly reported cases of microorganisms that resist antibiotic treatment. There are even warnings concerning the use of household cleaners that are labeled 'antibiotic' because of the fear of creating resistant 'super bugs' for which we currently have no treatment. Today the importance of using pesticides correctly is being stressed more than ever. Because of resistance, pesticides must be continually sprayed and in increasingly larger doses to achieve the same level of pest control. This treadmill of pesticide use can only result in the increase of resistant 'super bugs' and natural enemy loss.



Diversity Destroyed and the Attack of Killer Pests. *Broad-spectrum pesticide use is detrimentally altering the sustainability of our global ecosystem diversity. In addition, the resistance mechanisms of pest organisms are reducing pesticide effectiveness and resulting in the development of super organisms that are poised to take over the world. The use of chemicals as a control method in the future is increasingly becoming a less viable option.*

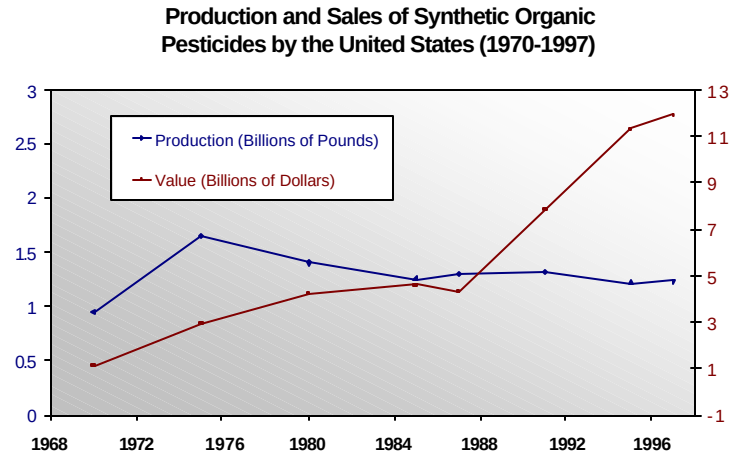
Chapter 6

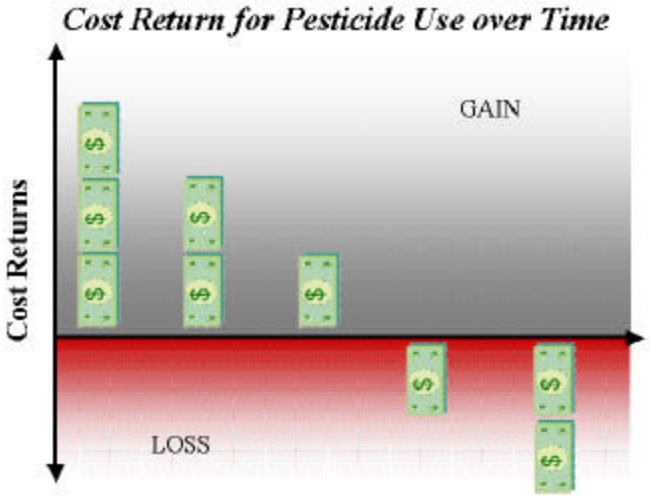
Economics of Pesticides

Transactional Costs

The losses of our earth's biodiversity and the increased cases of resistance are only some of the symptoms of continued pesticide use. The economics involved in the making, registering, regulating, and applying of pesticides are increasing dramatically. With FQPA regulations, companies now spend upwards of $100 million to register a chemical pesticide.

Pesticide users have also noted remarkable increases in the per-unit costs of new alternatives to pesticides (transactional costs). It costs between $35,000 to $3 million for the registration of alternatives that are designed to replace the older chemical pesticides. While alternatives are less expensive to register, they also tend to be less effective and less comprehensive than traditional pesticides. In addition, only companies that have the infrastructure to research, develop, register, and distribute a pesticide can even consider competing in the alternatives arena. As a result, companies are merging rapidly. By 2005, there may be as few as six pesticide companies left. These conditions result in a constraint on the innovation and development of alternatives being marketed by small companies. Therefore, market conditions, special interest activities, and increased regulatory requirements are concurrently working to change the cost of obtaining a greener lawn, less expensive food, or health protection.

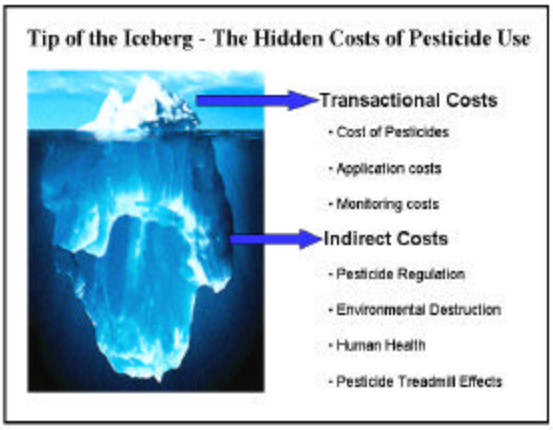




Indirect Costs

Direct transactional costs of pesticides are skyrocketing, causing more questions to arise concerning the feasibility of pesticide use. In addition, there are indirect costs associated with traditional pesticide use that may pose larger economic issues and may have long-term adverse consequences for society. New pesticides are becoming more and more expensive. Meanwhile, there is a lag in time before we can understand the subtle, often more costly, impacts of their use.

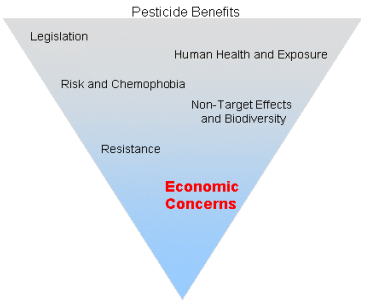
Assessing pesticide benefits and utility by their current transaction costs is misleading much like an iceberg hides most of its mass below the surface. Pesticide users may have the impression that there is a good profit return. However, these come from short-term measurable beneficial effects like the absence of certain pests, increased crop production, better food quality and appearance, etc. Once the indirect costs are added, society gets a different view of the hidden expenses of pesticide use: regulatory costs, effects of residues on human health, pest resistance, endocrine disruption, biodiversity loss, and environmental bioaccumulation. History has even revealed that some pesticides, like DDT, have yielded a massive negative return for each dollar invested. Such long-term consequences of pesticide use take on the less tangible, hard to measure price tag of intrinsic values to human life. Once these consequences become unveiled and are assessed, they prove to have enormous impacts that are not only extremely costly but potentially irreversible.



Short Term Solutions (pesticides) = Long Term Problems (indirect costs)

Potential monetary expenditures and indirect costs of using pesticides:

- ***Cost of cleanup for sites contaminated by pesticides***
- ***Loss of environmentally beneficial organisms and the cost to replicate their functions***
  ex. losses of honeybees from pesticide spray resulting in increased pollination costs to the farmer and a subsequent increase in produce costs for the consumer
- ***Loss of biodiversity and the cost of lost medicinal benefits derived from nature***
- ***Increased health costs for individuals who have been exposed to pesticides***
- ***Settlement costs for lawsuits involving pesticide exposures***



Remember the Titanic! *Pesticides have formerly been our indisputable, and seemingly indestructible, remedy for pests. However, given time and evidence, the use of pesticides for pest management may prove too costly in terms of production and intrinsic value losses. As a society, we must assess both the overt and the hidden costs of use or we risk losing the long-term sustainability of life on Earth.*

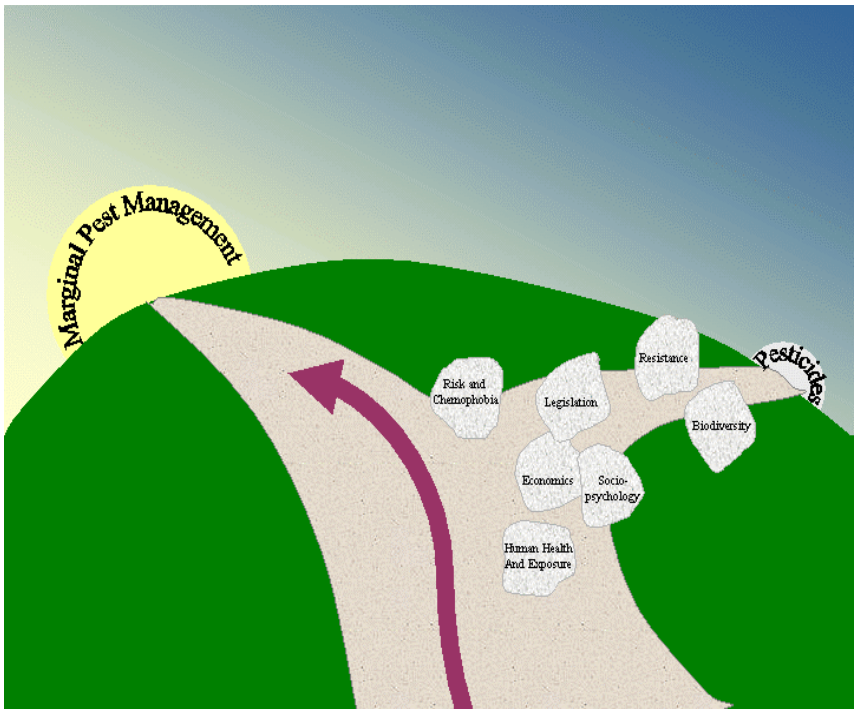
Chapter 7

Socio-Psychological Conclusions

An Anti-Pesticide Attitude

Over the years the arguments for discontinuing traditional pesticide use have become more and more prevalent. The concerns run the gamut from human welfare to environmental health, from conflicting presentations of information to questions of economic feasibility. Society has been inundated with media reports concerning negative pesticide health effects, problems with following regulations, costs and uncertainties involved in governmental research, effects of historical pesticide use, etc. When we look at the controversies that increasingly surround the use of pesticides, we become overwhelmed.

Conversely, when we look at the alternatives to pesticide use there appear to be fewer of these problems bearing down on us. Alternatives seem less messy and rarely present any of the problems that traditional uses do. Currently, alternatives have scant adverse health effects to humans or the environment. They are not so intricately and problematically regulated. Alternatives are safe, effective, and practical. In fact, alternatives appear to have only one substantial issue that can be used in argument against them: the cost of manufacture. Since they provide the path of least resistance, it is natural for society to congregate in the alternatives camp of pest management. As a result, we are increasingly headed toward and insist upon natural, environmentally friendly, and safe pest control.



An Utopist New World

Society has come to except nothing short of perfection. The misgivings concerning pesticide use may be unfounded or actual, but the issue is untidy at best. As a result, pest management solutions that are immersed in such controversy have no role in our world today. The only option for a sustainable future is to choose a pest management strategy that avoids such controversies and that accommodates the demands of society. Because no other option to date is as accommodating and viable as marginal pest management, society will have no choice but to follow that path. Therefore, in order to obtain perfection, society will choose no-demand marginal pest management tools that are perceived as natural, environmentally friendly, safe for fellow men and the environment, and providing a sustainable future. Only pest management tools that fit this profile - marginal pest management tools - will find a market in our consumer-driven society where the aim is the achievement of an utopist community.

Our Argument

- ***Pesticides have been the 'silver bullets' we use to mend the ills of the world.*** *We have been habituated to and dependent on pesticides to support a multitude of aspects of society's infrastructure. Pesticides are essential for feeding, clothing, and protecting people, plants, and animals, and we need them to sustain the quality of life to which we have become accustomed.*

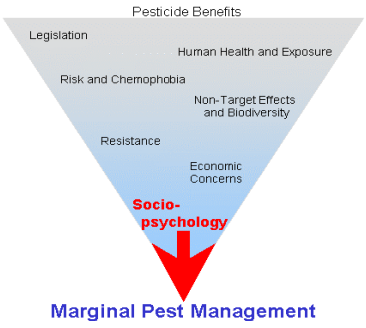
- ***Pesticides: Are our miracle cures falling from grace?*** *The globalization, 'greening,' and 'consumerism' of society have driven the implementation of regulations on pesticides, causing our 'silver bullets' to come under close scrutiny. Conflicting perspectives and confusion incited by these regulatory efforts and evaluation processes have diminished our hopes of continuing to use pesticides as 'silver bullets' in the war on pests, and are leading to a fast-paced transition away from pesticides toward alternatives.*

- ***Silent and Deadly: Are Pesticides Killing Us?*** *With prevalence in virtually every human environ and with symptoms that mimic common ailments, pesticides seem to be unknowingly and dangerously everywhere. Concern over environmental and worker exposures has lead to a heightened public concern and an erosion of society's confidence in the safety of pesticides.*

- ***Pesticides the Terrible: Perception is Reality.*** *Governmental agencies and research organizations strive to provide the most accurate information on pesticide risk while endeavoring to protect every individual from harm. Unfortunately, misrepresentations of scientific information continue to fuel the public's distrust of pesticides, pesticide producers, and the scientific community. In the end, society will demand nothing less than stricter protection from the tyranny of pesticide use.*

- ***Diversity Destroyed and the Attack of Killer Pests.*** *Broad-spectrum pesticide use is detrimentally altering the sustainability of our global ecosystem diversity. In addition, the resistance mechanisms of pest organisms are reducing pesticide effectiveness and resulting in the development of super organisms that are poised to take over the world. The use of chemicals as a control method in the future is increasingly becoming a less viable option.*

- ***Remember the Titanic!*** *Pesticides have formerly been our indisputable, and seemingly indestructible, remedy for pests. However, given time and evidence, the use of pesticides for pest management may prove too costly in terms of production and intrinsic value losses. As a society, we must assess both the overt and the hidden costs of use or we risk losing the long-term sustainability of life on Earth.*



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