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Agrochemicals' Benefits to Human Health and the Environment

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Executive Summary

This year marks the 50th anniversary of biologist Rachel Carson's 1962 book, *Silent Spring*, which argued that man-made chemicals represented a grave threat to human health and the environment. Using harsh and unscientific rhetoric—which was rebuked in the journal *Science* magazine shortly after its publication—Carson postulated that man-made chemicals affect processes of the human body in "sinister and often deadly ways."

History has proven Carson's claims wrong. Contrary to her admonitions, a chemically caused cancer epidemic never came to pass. Researchers who identified environmental factors did not simply target trace chemical exposures as significant, but instead focused on major cancer causes such as tobacco and poor diets. In fact, people are living longer and healthier lives, cancer rates have declined even as chemical use has increased, and chemicals are not among the key causes of cancer.

As the world reexamines Carson's anti-pesticide legacy, this paper focuses on the importance of chemicals designed for crop production. These agrochemicals represent a subset of the many technologies and practices designed to promote high-yield farming—making it possible for farmers to increase food production per acre. Other technologies include biotechnology, better soil and water management, among other things. Policies that allow strategic development and application of such tools will continue to facilitate the Green Revolution and increase agriculture's ability to feed the world's growing population. In addition, high-yield agriculture reduces the amount of land necessary to meet those needs, thereby providing more land for conservation and biodiversity. The adverse impacts of pesticides on human health and the environment are often greatly exaggerated and history shows that these risks can be managed to ensure substantial net benefits.

Unfortunately, these benefits are at risk as Carson's legacy of misinformation lives on within the politically organized environmental movement. Green activists oppose strategic pesticide spraying to control deadly diseases like the West Nile virus and advocate "organic farming" using "natural chemicals," even though there is little evidence that organic farming makes food any healthier. As a result, regulatory trends around the world have supplanted wise management with heavy regulations and product bans. The cost and risks associated with bureaucratic regulations alone dampens the market for innovative new products, diminishes the supply of pest control options for farmers, and reduces their efficiency. The result is lower food production, higher food prices, and fewer environmental benefits.

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Introduction

In 1996, the Competitive Enterprise Institute's Jonathan Tolman authored an article entitled "Rachel Was Wrong,"[1] in which he explained why biologist Rachel Carson mistakenly condemned chemicals—and pesticides in particular. This year marks the 50th anniversary of her 1962 book, *Silent Spring*,[2] which history shows is, in fact, still wrong.

Carson's supporters claim that the biologist made a reasonable call for prudent pesticide use. She noted in her book: "All this is not to say that there is no insect problem and no need of control. I am saying, rather, that control must be geared to realities, not mythical situations, and that the methods employed must be such that they do not destroy us along with insects."[3]

Yet her book's harsh and unscientific rhetoric about chemicals in general—which was rebuked in the journal *Science* magazine[4] shortly after its publication—took policy in the opposite direction. And while Carson called for policy based on reason over myths, she opened her book up with a "Fable for Tomorrow," describing a town in which chemicals have destroyed wildlife and people die from chemical exposures. She admitted it doesn't exist, but somehow we are supposed act on her myth because, "It might easily have a thousand counterparts in America."[5]

In her chapter, "Elixirs of Death," Carson postulates that man-made chemicals affect processes of the human body in "sinister and often deadly ways."[6] Regarding the pesticide DDT, which was then used to control malaria-carrying mosquitoes, she concluded that, "the threat of chronic poisoning and degenerative changes of the liver and organs is very real." In her book's chapter on cancer, "One in Every Four," she cites one expert who "now gives DDT the definite rating of a chemical carcinogen."[7]

Carson's crusade called for bans and regulations on more than DDT. She declared, "The most determined effort should be made to eliminate those carcinogens that now contaminate our food, our water supplies, and our atmosphere, because these provide the most dangerous type of contact—minute exposures, repeated over and over throughout the years."[8] Carson closed her chapter, "One in Every Four," by claiming that, "the most eminent men in cancer research" believe that "malignant diseases can be reduced significantly by determined efforts to identify the environmental causes and to eliminate them or reduce their impact."[9] Bans on modern chemicals must be implemented because "for those not yet touched by the disease [cancer] and certainly for the generations yet unborn, prevention is the imperative need."[10]

Carson's crusade called for bans and regulations on more than DDT.

Carson's anti-DDT rhetoric contributed to malaria outbreaks by encouraging many governments around the world to stop using it completely.

But contrary to her admonitions, a chemically caused cancer epidemic never came to pass. Researchers who identified environmental factors did not simply target trace chemical exposures as significant, but instead focused on major cancer causes such as tobacco and poor diets.[11] In fact, people are living longer and healthier lives,[12] cancer rates have declined even as chemical use has increased,[13] and chemicals are not among the key causes of cancer.[14]

Carson was particularly wrong about DDT. For decades before it was banned, humans were exposed to massive amounts of DDT without showing ill effect. Many scholars have well documented how Carson's anti-DDT rhetoric contributed to malaria outbreaks by encouraging many governments around the world to stop using it completely.[15] Limited and targeted uses of DDT could have saved millions of lives. Unfortunately, malaria now kills more than 1 million people and makes hundreds of millions seriously ill annually, mostly children in the developing world.[16]

Today, Carson's legacy of misinformation lives on within the politically organized environmental movement. Green activists oppose pesticide spraying to control deadly diseases like the West Nile virus, and advocate "organic farming"[17] using "natural chemicals," even though there is little evidence that organic farming makes food any healthier.[18] It is also true that, despite green contentions, organic farming is not necessarily better for the environment, which is the subject of this paper.

As the world reexamines Carson's anti-pesticide legacy, this paper focuses on the importance of chemicals designed for crop production. These agrochemicals represent a subset of the many technologies and practices designed to promote high-yield farming—making it possible for farmers to increase food production per acre. Other technologies include biotechnology, better soil and water management, among other things. Policies that allow strategic development and application of such tools will continue to facilitate the Green Revolution and increase agriculture's ability to feed the world's growing population.

Benefits of Pesticides

Agrochemicals, along with other important technologies such as biotechnology, help produce a growing food supply to feed the world's expanding population. A 2007 report by Jerry Cooper and Hans Dobson of the University of Greenwich highlights many of the benefits documented in the literature over the past several decades.[19] The authors explain that their overview is designed to provide a counterbalance to overly negative news coverage related to pesticides.

For example, the authors' survey of the news discovered that negative pesticide stories outnumber positive articles at a rate of 40 to one.[20]

The Cooper-Dobson review notes that pesticide benefits fall within three categories: social, economic, and environmental. This paper focuses on public health (a subset of social benefits) and environmental benefits. It does not focus on economic benefits directly, but those are also critically important to human health. Data demonstrates that wealthier populations are healthier.[21] But these indirect benefits fall outside the scope of this conversation.

Cooper and Dobbs document a host of benefits resulting from the increased agricultural productivity associated with agrochemicals. The ability of these products to control pests results in "greater availability of food, at a reasonable price, all year round."[22] It also means that as more food is produced per acre of land, less land is needed for agriculture, thereby increasing land available for conservation.

Consider some examples. The authors note that India has increased its grain production four times over since 1951,[23] and "now not only feeds itself but exports produce."[24] Farmers in the United Kingdom have increased the yield of wheat crops by 200 percent between 1948 and 1997.[25] U.S. corn yields have grown by more than 230 percent per acre between 1920 and 1980.[26]

Cooper and Dobbs acknowledge other factors that work in concert with agrochemicals to increase yield, including improvements in water and soil management. Dr. Erich-Christian Oerke of the University of Bonn takes a similar view, noting how crop protection products are among one of a number of important technologies and practices that have contributed to greater crop productivity. He explains:

> Despite a clear increase in pesticide use, crop losses have not significantly decreased during the last 40 years. However, pesticide use has enabled farmers to modify production systems and to increase crop productivity without sustaining the higher losses likely to occur from an increased susceptibility to the damaging effect of pests…Because of global population growth in a world of limits, sustainable crop production at elevated levels is urgently needed. The active control of crops and their genetics, of soil fertility via chemical fertilization and irrigation, and of pests via synthetic pesticides are hallmarks of the Green Revolution. The combined effect of these factors has allowed world food production to double in the past 40 years.

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Thanks to modern farming with chemicals, food production has outpaced population growth—providing people in both developed and developing countries with more food per capita.

> Diverse ecosystems have been replaced in many regions by simple agro-ecosystems vulnerable to pest attack. In order to safeguard the high level of productivity necessary to meet the human demand, these crops require protection from pests. The yield of cultivated plants is threatened by competition and destruction from pests, especially when grown in large-scale monocultures or with heavy fertilizer applications.[27]

While it is difficult to separate out the benefits of crop protection products from those of other technologies such as plant breeding biotechnology, the evidence, explains Washington State University professor Allan S. Felsot in a 2011 paper he authored for the American Council on Science and Health, "shows that both types of technologies have had major contributions."[28] For example, he notes that the productivity of potatoes exploded after 1950 thanks to the introduction of fumigants to reduce the impacts of nematodes. Yields grew from 153 100-lb. bags (cwt) per acre in the 1950s to 752 cwt per acre—a nearly 400 percent increase.[29]

Cooper and Dobson maintain that the application of "pesticides has undoubtedly played a very significant role." According to one study they reviewed, "without pesticides, apple production would not be commercially viable and farmers would have to use their land for other purposes."[30] Similarly, Russian farmers increased apple orchard yields by one and a half to two times and increased marketable produce by 80 to 90 percent after beginning pesticide applications.[31] In Zimbabwe, the use of fungicides makes growing tomatoes possible during the rainy season. Without these technologies, farmers there would likely suffer "total crop failure" during that time of year.[32]

Herbicides have also yielded a number of clear benefits important to agricultural productivity. Cooper and Dobson note the importance of herbicides, which "represent around 50 percent of all crop protection chemicals used throughout the world, compared with insecticides and fungicides that are around 17 percent."[34] Herbicides have some direct benefits to farm workers because they replace arduous mechanical harvesting of weeds. Mechanical weed removal also raises the costs of farming and thereby increases food prices. Also, it is often less effective in controlling these pests, thereby reducing yield.

Health Benefits

Thanks to modern farming with chemicals, food production has outpaced population growth—providing people in both developed and developing countries with more food per capita and helping in the battle against star-

vation and malnutrition. Per capita grain supplies have grown by 27 percent since 1950, and food prices have declined in real terms by 57 percent since 1980.[34] At the turn of the 20th century, before the use of modern agricultural practices, Americans spent 20 percent of their income on food. Today the average American family spends less than 9 percent of its disposable income on food.[35]

In addition to combating hunger and starvation, more affordable fruits and vegetables is the best defense against many illnesses, including cancer. The quarter of the U.S. population consuming the least amount of fruits and vegetables has a cancer rate twice as high as the quarter of the population consuming the most fruits and vegetables.[36] Accordingly, the World Health Organization advocates increased intake of fruits and vegetables, to reduce the cancer incidence rate by 30 percent across the board.[37] By making fruits and vegetables more affordable, high-yield agriculture facilitates greater consumption of these cancer-fighting foods.

Less obvious health benefits associated with pesticides include their ability to restrain the natural development of toxic substances in food products. When plants are exposed to pests without the use of pesticides, they will develop their own defense mechanisms that include highly toxic naturally occurring chemicals. For example, Cooper and Dobson note that "cereal diseases" can result when farmers do not use fungicides, which can create toxins that make humans sick and can even prove "lethal" in extreme cases.

Interestingly, agrochemicals are not only applied to the land, they are also used to defend farm animals from disease. For example, applications of pesticides to livestock in Burkina Faso, in Africa, helps prevent transmission of trypanosomiasis—a potentially fatal disease transmitted to animals and humans from tsetse flies. These applications reduced livestock mortality by 63 percent, increased offspring survival by more than 50 percent, and increased milk yield. As a result, herd sizes grew by 25 percent, making it possible for more households to own oxen, which were also each more productive.[38]

Pesticides also reduce risks related to a host of vector-borne diseases by controlling populations of mosquitoes, ticks, cockroaches, rodents and other pests.[39]

Agrochemicals are also used to defend farm animals from disease.

Environmental Conservation Benefits

While many environmental advocacy groups suggest that chemicals have tremendously adverse impacts on the environment and wildlife, the fact is that these products have substantial environmental benefits. We consider a few here, such as the impacts on habitats and water quality.

High-yield farming helps reduce encroachment into wildlife habitat.

Researcher Roger Sedjo of Resources for the Future notes: "Almost certainly the primary cause of contemporary biodiversity decline is habitat destruction and the degradation that results from the expansion of human populations and activities."[40] Clearing land for agriculture is surely one of those human activities, as is clearing land for living space.

Many people assume that any deforestation is bad. They forget that deforestation has made it possible for developed nations to provide an abundant food supply for domestic and international markets. As populations grow and people switch from gathering food to farming, some deforestation becomes necessary. History shows that once enough agricultural land is set aside and farming practices become sustainable, forests stabilize.

Steven Hayward of the Ashbrook Center at Ashland University documents such trends in his *Environmental Almanac 2011*, showing how deforestation has declined in recent years in many parts of the world and in some cases reforestation has begun. He notes:

> Although data on the global scale are inconsistent and incomplete, the rate of deforestation appears to be steadily declining. Between 1995 and 2005, Asia dramatically reversed its deforestation trends; it is now reforesting rapidly. Africa and South America still experience the highest rates of deforestation.
> Brazil, which along with Indonesia had the highest net loss of forests in the 1990s, has significantly reduced its rate of loss. Recent data suggest that Indonesia's rate of deforestation is also slowing.[41]

Such reforestation would not be possible without high-yield agriculture and the chemicals that are part of that process.

From a conservationist perspective, the problem is not deforestation and habitat destruction, per se, but mismanagement of resources. This is true for both the developed and developing world. A large part of the problem stems from the tragedy of the commons—the fact that much of the world's forests are owned by central governments that do not exercise any management or control over the lands. As a result, much of the forests are an open resource lacking a steward, which leads to serious abuse as everyone takes from the forest, yet no one has an interest in maintaining the resource. In addition poverty contributes as clearing more and more land for agriculture becomes necessary to produce food.

There is much debate as to the extent of rainforest deforestation. It is clear that high-yield farming helps reduce encroachment into wildlife habitat, and the measured impact is substantial.

If farmers continued to use 1950s technology—when most of the world did not use pesticides and fertilizers—they would have to plant 10 million square miles of additional land to generate the food that is produced today, notes researcher Dennis Avery of the Hudson Institute.[42] That is more land than all of North America (about 9.4 million square miles) and almost as much as all the land in Africa (about 11.7 million square miles). Researcher Indur Goklany has also quantified these conservation gains. He explains:

> If U.S. agricultural technology had been frozen at 1910 levels—i.e. if cropland per capita had stayed at 1910 levels—then to produce the same output as achieved in 2004, U.S. farmers would have had to utilize 1,007 million acres rather than the 305 million acres that were actually harvested that year. That's more than four times the total amount of land and habitat under special protection in the U.S. in 1999—including National Parks, National Wildlife Refuges, and National Wilderness Areas. Quite possibly, the increase in land productivity averted a potential catastrophe for U.S. wildlife and perhaps even biodiversity more generally.[43]

The use of chemical herbicides produces another set of environmental benefits. Before the 1960s, farmers relied on tilling the soil to control weeds, a practice that led to sediment runoff into nearby waters. Such sediment blocked sunlight out of streams and waterways, killed vegetation and harmed wildlife. "Many environmental scientists agree" Felsot explains, "that eutrophication and sedimentation of aquatic resources due to runoff and erosion from agricultural land is the most important cause of water quality impairment, not to mention being responsible for transportation problems as rivers backfill with sediment."[44]

The answer to this problem came from no-till and conservation tillage (reduced tilling) for farming, a practice made possible by chemical herbicides. Using herbicides to control weeds decreases the need for tilling soil, which, in turn, reduces soil erosion by 50 to 98 percent, notes Avery.[45] Felsot notes that soil erosion resulting from tilling in Illinois, Indiana, Iowa, and Nebraska amounted to 14.9 tons/acre/year, whereas no-till farms there released only 0.8 tons/acre/year.[46]

One of the key herbicides used that make no-till farming possible is atrazine. A target of environmentalists who say it pollutes waterways, atrazine is one of the most studied chemicals in the world and is widely recognized as posing negligible health and environmental impacts.[47]

At a November 2011webcast conference, a number of U.S. researchers

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pointed out the critical value that atrazine has had on production in the United States. David C. Bridges, Ph.D., president of the University of Georgia's Abraham Baldwin Agricultural College, explained, "It's hard to overestimate the importance of atrazine and the triazine herbicides to U.S. agriculture and global food supplies. They benefit food production, the environment and the economy—and that means jobs… Some say there are ready replacements. In fact, there is no substitute for atrazine."[48] According to Bridges, atrazine increases corn production by 7 bushels per acre, and sorghum farmers gain an additional 13 bushels per acre.[49]

According to Paul D. Mitchell of the University of Wisconsin, the use of atrazine and other triazine herbicides in the United States adds a total of $3.8 to $4.8 billion per year to the U.S. economy. In addition, by reducing the need for tillage, these products reduce soil erosion in the United States by 56 to 85 million tons per year. That results in $210 to $350 million per year in benefits to the U.S. economy. These products also reduce the amount of diesel fuel that otherwise would be used to operate tilling machinery—saving 18 to 28 million gallons per year.[50] Mitchell explains:

> Atrazine and the other triazine herbicides have contributed to the observed decrease in soil erosion by providing an effective residual herbicide for weed control in conservation tillage and no-till systems. If triazine herbicides were not available to U.S. farmers, this analysis shows that aggregate soil erosion from U.S. cropland would begin to increase and reverse the tremendous advances in soil management that U.S. farmers have made in the last 30 years to reduce soil erosion.[51]

Atrazine and similar herbicides have done more to help wildlife than hurt it. Researcher Richard S. Fawcett stated it well at the 2011 November conference: "We do know that wildlife habitat has been greatly improved. Conservation tillage created habitat, benefits ecology …When I was a kid, you would never see wildlife on a farm, but today you do. The wildlife is back."[52]

Risks Associated with Agrochemicals

Health Risks. While the benefits of agrochemicals are substantial and clear, they must also be weighed against the risks. Environmentalists often call for regulation on the grounds that man-made chemicals used in consumer products pose a serious cancer risk. Yet in their landmark 1981 study of the issue, renowned scientists Sir Richard Doll and Richard Peto outline the widely understood and accepted causes of cancer in the United States. According to Doll and

Peto, 80 percent to 90 percent of cancers are caused by "environmental factors."[53] Although activists often trump this figure as evidence that industrial society is causing cancer, Doll and Peto explain that environmental factors are simply factors other than genetics—not pollution alone.

Pollution—including pesticide residues— accounts for only 2 percent of all cancer cases.[54] Tobacco use accounts for about 30 percent and dietary choices for 35 percent of annual cancer deaths. Bruce Ames and Lois Swirsky Gold of the University of California, Berkeley, came to similar conclusions, noting that smoking causes about a third of all cancers. They underscore the importance of diet by pointing out that the quarter of the population eating the fewest fruits and vegetables had double the cancer incidence than those eating the most. Finally, they conclude: "There is no convincing evidence that synthetic chemical pollutants are important as a cause of human cancer."[55]

In contrast, environmentalists point to "evidence" of cancer caused by man-made chemicals based on the fact that rodents get cancer when given massive doses of chemicals. Yet these studies have little relevance to humans exposed to trace amounts of those chemicals. In fact, high doses of many naturally occurring products—including broccoli, carrots, and coffee—also give rodents cancer.[56] It is the dose that makes the poison.

Given the poor data related to chemicals and cancer, environmental activists have also suggested that chemicals pose another problem. They maintain that some man-made chemicals mimic human hormones and thereby cause a host of health problems, including developmental ones. In reality, trace chemicals found in consumer products and in the environment do not have enough potency to have any such effects. In fact, humans are exposed to such endocrine mimicking chemicals via a host of natural sources—such as legumes—that are hundreds of thousands of times more potent yet pose no significant risks.[57]

Pesticide residues rarely, if ever, approach unsafe levels. Even when activists cry wolf because residues exceed federal limits that does not mean the products are dangerous. In fact, residues can be hundreds of times above regulatory limits and still be safe. According to one National Research Council (NRC) report, "[T]he great majority of individual naturally occurring and synthetic chemicals in the diet appears to be present at levels below which any significant adverse biological effect is likely, and so low that they are unlikely to pose any appreciable cancer risk."[58] The American Academy of Pediatrics notes: "The risks of pesticides in the diet are

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remote, long-term, and theoretical, and there is no cause for immediate concern by parents. The risks to children over their lifetime of experiencing the major chronic diseases associated with the typical American diet far exceed the theoretical risks associated with pesticide residues."[59]

Various government agencies test produce for residues to ensure that they meet safety standards. The U.S. Food and Drug Administration (FDA) and the state of California conduct the most comprehensive and regular testing. Both find not only that residue levels are far lower than any U.S. Environmental Protection Agency (EPA) standard, but also that they are most often undetectable. Residue levels decline even further when we wash produce. One study shows that washing fruits and vegetables can reduce exposure by 97 percent for some pesticides.[60]

Most residues are undetectable in developed nations, demonstrating that they can be used responsibly to keep human exposure to negligible levels. In one survey, the FDA reported: "The findings for 2003 demonstrate that pesticide residue levels in foods are generally well below EPA tolerances, corroborating results presented in earlier reports."[61] In fact, 62 percent of domestic fruit and vegetable samples and 83 percent of imported fruit and vegetable samples had no detectable pesticide residues. Only 2 percent of domestic and 6 percent of imported fruit and vegetable samples exceeded standards. Pesticide residue tolerances were in compliance with FDA standards on 92.9 percent of all imported fruit and vegetable samples. The FDA reported no residue violations for domestic grains and violations for only 1.4 percent of imported grains. The agency found no violations for dairy and egg products and for seafood and no residue violations in baby foods.

There are cases of serious health effects associated with acute poisoning from pesticides. However, the risks are relatively low given the widespread use of the products and the value they bring in terms of health benefits and food security. For example, a study of statistics and report on illnesses of U.S. farm workers—the subset of the population that is most exposed—related to pesticides between 1998 and 2005 found that the overwhelming majority of cases (87 percent of 3,271 documented illnesses) were of low severity (such as temporary irritations).[62] Only 12 percent were considered "medium severity" (a category not well defined), 0.6 percent of cases were considered "serious," and one was fatal. While we also would hope for no such illness to result, risks are endemic to every activity in life. Despite all the hype about chemicals these numbers are quite low, considering the number of years covered and limited adverse

impacts. On a positive note is the fact that such cases have declined since the 1980s.[63]

Similarly, even when pesticides are sprayed within residential areas, risks are low and manageable. Consider the Centers for Disease Control and Prevention (CDC) data on documented cases of health problems related to pesticide exposures from spraying during 1999-2002 to control mosquitoes carrying the West Nile virus. If spraying-related health problems are as rampant as environmental activists suggest, we should expect some significant documentation of cases. But the CDC data indicate that the number of cases were very small and the impact only temporary. According to the CDC report, there were two cases of definite health impacts, 25 probable cases, and 106 possible cases. No deaths were reported. That is a total of 133 potential cases of temporary illness over four years among a population that CDC estimates was 118 million in 2000. Despite what environmental activists might claim, that is a pretty impressive record of success. CDC points out: "The findings in this report indicate that serious adverse outcomes potentially related to public health insecticide application were uncommon. When administered properly, in a mosquito-control program, insecticides pose a low risk for acute, temporary health effects.[64]

Risks to the Environment. The impact of pesticides on wildlife depends on how they are used. Misuse can have adverse effects, but limited, targeted use enables us to enjoy the benefits to both humans and wildlife without destroying species. In fact, as noted, the substantial benefits related to wildlife habitat and reduced pollution related to tillage indicates that on balance pesticides do considerably more good than harm. A publication of the Virginia agricultural extension provides some perspective:

> Pesticides are beneficial chemicals. They can protect against forest and farm crop losses and can aid in more efficient food production. They are used to slow the spread of destructive forest insects like the gypsy moth. They are used to establish and maintain lawns and recreational areas. They are used to help reduce malnutrition and starvation of humans and animals. Pesticides also have been instrumental in controlling many insect-borne human diseases such as malaria, encephalitis, and bubonic plague. They promote public safety on roads, railroads, powerlines, and rights-of-ways.
>
> When pesticides enter aquatic systems, the environmental costs can be high. Unintentional pesticide-related fish kills occur throughout the United States.

Even when pesticides are sprayed within residential areas, risks are low and manageable.

Environmental organizations manage to gain headlines by presenting misleading information about the scope of pesticide impacts on wildlife.

> Some of these kills have been large, involving thousands of fishes, as well as frogs, turtles, mussels, water birds, and other wildlife. Fish and other wildlife species, including rare and endangered ones like the peregrine falcon, bald eagle, and osprey, have been victims of pesticide poisoning. Pesticide use is one of many factors contributing to the decline of fish and other aquatic species. Protection of wildlife and water quality is possible when using pesticides. If pesticides are selected wisely, used in combination with other pest control measures, and applied safely, the pollution of our surface waters and contamination of aquatic life can be avoided.[65]

Many environmental groups condemn all use of agrochemicals by focusing on bird and other wildlife deaths that are potentially related to pesticides as well as highly speculative estimates about pesticide-related bird mortality. They fail to examine the entire picture: whether pesticides have a significant impact on wildlife survival to assess whether the overall impact is positive or negative. But focusing on individual incidents of bird poisonings to draw conclusions about pesticide impacts on overall wildlife health is misleading and not particularly helpful. The more critical point is how significant those cases are to the overall survival of species and biodiversity.

There have been some attempts at a more comprehensive quantification of the human impact on bird mortality, including pesticide use. Out of an avian population that can amount to 20 billion during fall migration in North America,[66] the U.S. Fish and Wildlife Service (FWS) estimates that pesticides cause about 67 million bird deaths a year, some of which may be intentional killing of pest birds. These are largely speculative estimates, and are not based on actual body counts or sampling of carcasses to determine cause of death.[67]

Even if the FWS estimate were valid, it remains unclear as to whether pesticides have a significant impact on overall species populations and survival. While this number may sound substantial, it represents just 7.1 percent of *human-caused* bird deaths, falling behind such things as bird collisions with buildings (550 million/58.2 percent), impact with power lines (130 million/13.7 percent), cats (100 million/10.6 percent), and automobiles (80 million/8.5 percent).

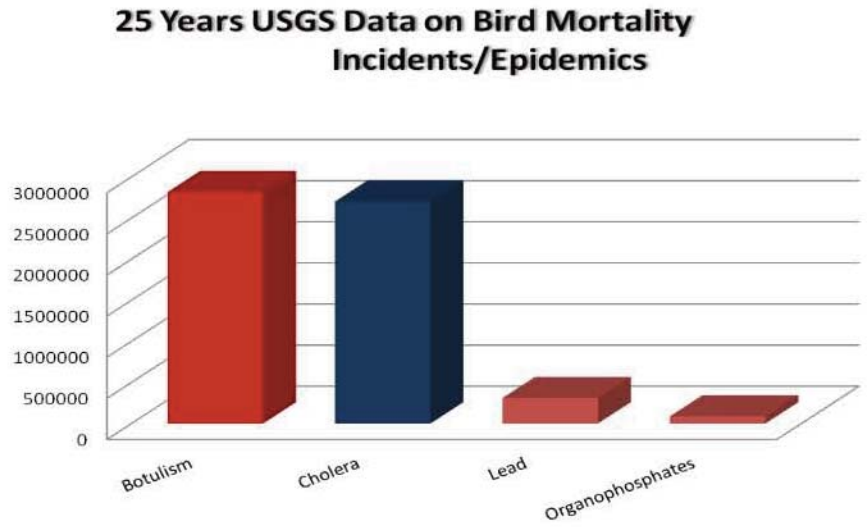
Still, environmental organizations manage to gain headlines by presenting misleading information about the scope of pesticide impacts on wildlife. For example, they made a host of unsubstantiated claims about the impact of pesticides on bird mortality

during the early years of the West Nile virus outbreaks in the United States.

Starting in 1999, New York State researchers collected thousands of dead birds to study the spread of the West Nile virus. That year, the U.S. suffered its first ever outbreak of the virus, which is transmitted to both humans and birds via mosquito. Collecting dead birds and studying the causes of death enabled them to map how far the disease had traveled. In 2001, the New York chapter of the Audubon Society claimed that state government researchers found that most of the birds had died from pesticides rather than West Nile.[68] But the group failed to provide data and the state did not release any statement or study to demonstrate that fact. Journalist Steve Milloy reported that he accessed the data, and it showed that a large majority of the birds tested had most likely died from *natural* toxins and diseases, such as botulism.[69]

Milloy's report is more plausible. Bird mortality related to disease is far better documented than avian mortality related to agricultural and public health uses of pesticides. Diseases such as botulism cause massive bird die-offs, sometimes killing more than 1 million birds at a time in one outbreak.[70] Birds also suffer from numerous other diseases as well as predation from other birds and animals.[71]

Data from the U.S. Geological Survey (USGS), a division of the Department of Interior, provides a sampling of the major causes of avian mortality. USGS has been collecting data and studying wildlife diseases for decades.[72] It does an impressive job reporting extensive deaths related to natural diseases, with reports covering birds found mostly on public lands. It shows that many mass die-offs of species occur from natural causes. Far fewer incidents are related to illegal and/or excessive use of pesticides, which the



Survey also assesses. In particular botulism epidemics kill thousands of birds, as does the West Nile Virus.

Some U.S. states also test birds for disease and pesticide poisoning. Michigan reports its findings in the state's *Wildlife Disease Manual*,[73] which has two entries on pesticides. Both note that state officials rarely find pesticide poisonings. In contrast, they provide a lengthy list of mortalities from natural diseases. Under the heading "Significance" in each section, these pesticide entries conclude:

> Occasional organophosphate poisonings are seen in Michigan wildlife following exposure to recently treated areas. Diazinon intoxication in Canada geese, mallard ducks and wild turkeys is the most common organophosphate poisoning seen. Parathion poisoning in ring-billed gulls and disulfoton intoxication in a mallard, sevin poisoning in bees, and chlorpyrifos poisoning in a mallard have occurred as the use of organophosphates has increased. These deaths are usually sporadic and infrequent in occurrence.[74]

And …

> Mortality in wildlife due to chlorinated hydrocarbon poisoning is seldom observed in Michigan anymore. Due to the banning of many of the highly toxic chlorinated hydrocarbon compounds in the 1970's, the possibility of exposure today is rare. The importance of these compounds to humans is comparable.[75]

A 2007 study published in the journal *Nature* documents how just one disease—West Nile virus—can impact species populations. The authors note:

> Observed impacts included steep and sometimes progressive multiyear declines in regional populations of American crows, American robins, chickadees and eastern bluebirds, which were all increasing before WNV arrival. Other species, including blue jays, tufted titmice and house wrens showed strong 1- or 2-yr declines after intense WNV epidemics, but little or no impacts at other times.[76]

Many bird species recovered in subsequent years after the more serious West Nile outbreaks in 2003 and 2004, but West Nile virus continues to be a challenge with 2012 becoming one of the worst outbreak years yet.[77]

Thus far, diseases and habitat loss appear to be the most significant challenges to birds and other wildlife. Fortunately, there is evidence that even in places where chemicals are used widely in agriculture, such as

the United States, wildlife biodiversity is improving. For example, Steve Hayward documents in his *Environmental Almanac 2011* that the FWS report's substantial improvement in fisheries during the past decade as well as improvement in bird populations based on the Audubon Society's annual bird count.[78] Regarding birds he notes: "In four out of five habitat types (the exception is grasslands), increasing or stable bird populations were more predominant than declining populations."[79]

Kevin McGowan of the Cornell Laboratory of Ornithology in New York told *Live Science*, "Birds are increasing and that's good.[80] People have worked hard to do that kind of thing. Most people like it. We don't always hear enough about the fact that a lot of things are doing well."[81] For example, he noted that while some common species have experienced declines, more than half of the bird populations that experienced population changes have increased their numbers, based on his study of New York State birds.

High-yield agriculture, including measured use of pesticides, plays a role in bird recovery by creating more space for wildlife. This is particularly important given the fact that habitat loss is most likely the biggest challenge to species. While many people remain concerned about pesticides, proper use can ensure minimal impacts. And given the benefits that pesticides produce for both wildlife and humans and the manageable risks to both, the goal of public policy should be to expand their judicious use to places where the benefits are not yet fully realized.

Challenges

After decades of progress in expanding agricultural yields and declining prices, recent years present an unwelcome trend as world food prices have begun to increase when adjusted for inflation. The United Nations' Food and Agriculture Organization (FAO) notes, "The sudden increases took many by surprise, and led to increased concern over the ability of the world food economy to adequately feed billions of people, now and in the future."[82]

According to the Organisation for Economic Cooperation and Development (OECD)-FAO Agricultural Outlook 2011-2020, food production is expected to only grow by 1.7 percent per year, a much slower rate than the 2.6 percent growth rate of the prior decade."[83] Identified causes include bad weather, use of commodities for biofuels, depreciation of the U.S. dollar, increased demand for meat and need for feedstock, rising production costs, reduced investment in rice and wheat crops, and trade policies.

Meanwhile population will continue to expand. Séan Rickard of the Cranfield

High-yield agriculture, including measured use of pesticides, plays a role in bird recovery by creating more space for wildlife.

Without pesticides, the price of raising a crop could increase by five to 200 times, and those costs would be transferred to consumers in the prices of the goods.

School of Management notes in his 2010 study on crop protection products that world population will grow more than a third of its existing size by 2050, increasing the demand for food substantially in decades to come. Most of the growth is expected to occur in developing nations, where as Rickard notes, "agricultural industries lag behind the more advanced, highly efficient farms typical of North America and Western Europe."[84] Accordingly, use of chemicals and other technologies such as biotech should be expanded in these nations to ensure a growing food supply.

Unfortunately, policy trends in developing nations are moving in the opposite direction, applying increasingly stringent regulation on these technologies. These products are regulated—and some banned—despite the failure of regulators to demonstrate that the products are dangerous. Rather, policy is now driven by the "precautionary principle," a standard that calls for regulation even in the absence of demonstrated risk and scientific justification. It also fails to measure or even consider the benefits of products that are lost as regulators restrict use.

To gain some perspective on what is at stake, a number of studies have assessed the likely impacts should farmers completely abandon chemical controls or if governments were to ban all such products. Without pesticides, the price of raising a crop could increase by five to 200 times, and those costs would be transferred to consumers in the prices of the goods, according to one estimate.[85] As Scientist Philip Abelson warned, the continued banning of pesticides and fungicides could lead to food scarcities.[86]

Rickard estimates that elimination of agrochemicals would "severely" reduce food security, which would be reflected in much higher food prices. "In the UK the cost of food would rise by about 40 per cent, increasing food and drink expenditures by some £70 billion [about $112 billion] per year and raised to the level of the EU this implies additional food expenditures of some £750 billion [about $1.2 trillion]," the study notes.[87]

Researchers Leonard Gianessi and Nathan Reigner note:

> If U.S. growers stopped using herbicides and resumed tillage on the 62 million acres that were not tilled in 2005, soil erosion would be 356 billion pounds higher than it is today. Soil erosion deposits sediments in streams and rivers resulting in downstream damages. The damage resulting from increased soil erosion due to farming without herbicides is estimated at $1.4 billion.[88]

Moreover, lower productivity in developing nations will increase pressure for farmers to move into marginal lands, limiting space for wildlife.

European Union: Sustainable Use Directive. In 2009, the European Union (EU) passed the Sustainable Use Directive, which empowers regulators to restrict or ban pesticides based on a products "hazard" profile rather than as a result of a scientific assessment of potential or likely risks to human health or the environment. Specifically, it applies what is called the "hazard-based cut-off," which grants regulators the authority to ban products based on whether chemicals fit within certain categories. These include carcinogenic; mutagenic; toxic for reproduction; endocrine disrupting; persistent; bioaccumulative and toxic (PBT); persistent organic pollutant (POP); and very persistent, very bioaccumulative (vPvB).

Regulators may allow a "hazardous" product to remain on the market under two exemptions: 1) The estimated human exposure is "negligible"; or 2) The product is necessary to address "a serious danger to plant health," suitable alternatives are not available, and regulators can identify and ensure measures to mitigate any adverse impacts.[89]

This focus on "hazard" as a justification to regulate is highly problematic. "Hazard" simply represents the potential for danger given specific circumstances or exposures. For example, water is hazardous because excessive consumption can produce fatal "water intoxification" or hyponatraemia. Likewise, we have many "hazardous" products in our homes—everything from cleaning supplies to bug spray to olive oil (which can make you slip if spilled on the floor, but the risk depends on how we use them). Fortunately, we can benefit from each of these products while managing the risks to keep them low.

We have many "hazardous" products in our homes, but the risk depends on how we use them.

A "hazard" profile offers no good scientific justification to regulate pesticides any more than it does to support regulations or bans on water. In fact, many chemicals could be called hazardous simply because they give rodents cancer when the animals are dosed massive amounts. Yet so do broccoli, almonds, and many other healthy foods. Often, it is the dose that makes the poison. As a result, many chemicals that are perfectly safe to use could be removed from the market simply because of this "hazard" profile, even when scientific risk assessments indicate that existing uses pose negligible risk. This anti-scientific approach prompted 160 scientists to sign a petition opposing the 2009 pesticide directive.[90]

Pesticides on the market in Europe have already been studied and regulated to ensure safe use, but the new law is

forcing reevaluation of them all. The process is ongoing, but "most substances are to be evaluated between 2014 and 2019," notes Euros Jones of the European Crop Protection Association.[91] Shortly after the law was passed, the European Union banned 22 pesticides.[92]

Fortunately, the slow nature of bureaucracy has led to delays in pesticide bans in Europe. The EU was slated to consider bans on 31 products in 2012, but has delayed such decisions until 2018.[93]

Arguably, the EU was already over-regulating pesticides before the 2009 law passed. One manufacturer noted recently that the industry had already lost more than 600 product uses and is "already experiencing some serious problems controlling weeds, diseases and pest problems, especially in minor crops,"[94] Yet the Pesticides Safety Directorate in the United Kingdom notes that there will potentially be more productivity losses for farmers as a result of the 2009 pesticide law.[95] Rickard notes: "The result has been a slowing down in the EU industry's research activity and a lowering of the capacity in Europe to bring new plant protection products to the market compared to the United States."[96]

United States: Food Quality Protection Act

The United States has yet to apply a fully hazard-based pesticide law, yet its pesticide regulations are extremely precautionary and have produced a number of product bans. The current law, the 1996 Food Quality Protection Act (FQPA), was designed to replace an old standard called the Delany Clause, which regulated pesticide residues on processed food. It prohibited the addition to food of any substance that had been shown to cause cancer in laboratory animals. The Delany Clause was so excessively precautionary that lawmakers and agricultural interests feared it would eliminate many valuable agrochemical products without sound justification.

Passed by a Republican Congress seeking to curb regulatory excesses, the FQPA adopted a risk-based standard that limited residues on all foods—both processed and unprocessed—to a level that ensured "a reasonable certainty that no harm will result from aggregate exposure."[97] Despite contentions by supporters that the standard would be less stringent, the new law in fact proved *more* stringent than its predecessor. One observer commented: "No, you may not gain peace of mind when discovering that the new standard is stricter than Delaney, at least the way EPA and FDA was interpreting it."[98]

However, the "no harm" language suggests a zero-risk standard, and aggregate exposure considerations added a new level of precaution. The new law also demanded that regulators

apply an additional 10-fold safety factor for any product to which children might be exposed, in addition to safety factors they already employed. Shortly after Congress passed the FQPA, University of Texas professor Frank Cross pointed out in a law review article that EPA's conservative risk estimates were already excessively cautious, overstating pesticide exposure thousands and even hundreds of thousands of times beyond the most likely actual exposure levels.[99] And the FQPA has added factors of caution beyond even that, leading to the removal of many products from the market. While it is important to ensure that products are safe, the FQPA has moved beyond that concern to eliminate beneficial products that pose minimal risks when used properly.

During the first 10 years of the FQPA's life, the EPA completed a 10-year study of 230 organophosphates and carbonates pesticides. It concluded that the Act demands that the agency ban 3,200 uses of pesticide products in these categories and place restrictions on 1,200 other uses. It deemed 5,237 uses as "safe" under the Act.[100] That is 46 percent of the uses of the 230 chemicals— a substantial increase of regulations using FQPA's risk-based standard.

Attempts to curb such regulatory excesses have taken the form of regulatory oversight laws that focus on the regulatory process in general, rather than reforms to the underlying basis of these laws. By and large, these efforts have not proven particularly effective in either curbing precautionary environmental policy or promoting rigorous risk-assessment and cost-benefit considerations as criteria for environmental regulation.[101]

Conclusion

The world has reached a critical point in terms of food production. For decades, modern farming practices continued to advance, providing hope and promise that agricultural production would increase enough to feed a growing world population, while still freeing space for wildlife conservation. Yet modern, anti-technology trends—particularly those against agrochemicals—threaten this progress because of misguided claims associated with these products. While many in the developed world may be able to shoulder some of these costs, the world's poor will suffer disproportionately should production on per–acre yields continue to slow or decrease. While some groups push these policies to protect wildlife, the policies will increase the demand for planting more land—even marginally productive lands—thereby undermining wildlife biodiversity.

While it is important to ensure that products are safe, the FQPA has moved beyond that concern to eliminate beneficial products that pose minimal risks when used properly.

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