

DDT: A Case Study in Scientific Fraud

J. Gordon Edwards, Ph.D.

ABSTRACT

The chemical compound that has saved more human lives than any other in history, DDT, was banned by order of one man, the head of the U.S. Environmental Protection Agency (EPA). Public pressure was generated by one popular book and sustained by faulty or fraudulent research. Widely believed claims of carcinogenicity, toxicity to birds, anti-androgenic properties, and prolonged environmental persistence are false or grossly exaggerated. The worldwide effect of the U.S. ban has been millions of preventable deaths.

Fraud in science is a major problem. A 2002 report published by the American Association for the Advancement of Science (AAAS) on “fraud in science in Germany” stated that International Scientific Misconduct Rules should “punish deliberate or grossly negligent falsification or fabrication of data,” and that “failure to cooperate with investigations will be considered an admission of guilt.” Ombudsmen will be appointed “to probe for examples of misconduct, including falsification, fabrications, selective use of data, and manipulation of graphs and figures.”¹ Upon reading this article, I prepared a 34-page list of frauds published in U.S. scientific journals and sent it to the editor of *Science*. Although he responded courteously, he evidently did not wish to publicize this.

The most common examples of fraud in the United States appear to be environmental, including acid rain, ozone holes, carbon dioxide, ultraviolet radiation, global cooling, global warming, endangered species, and pesticides. This article will primarily concern the last, especially DDT.

Value of Pesticides to Humanity

DDT (dichlorodiphenyltrichloroethane) was first produced in 1874 by German chemist Othmar Zeidler, but he did not suggest any actual use for it. Sixty years later, Paul Müller duplicated the procedure and discovered the chemical’s insecticidal potential. For this, he received the Nobel Prize in 1948.

DDT has been effective in controlling mankind’s worst insect pests, including lice, fleas, and mosquitoes. This was of enormous importance for human health because at least 80 percent of human infectious disease worldwide is arthropod borne.² Hundreds of millions have died from malaria, yellow fever, typhus, dengue, plague, encephalitis, leishmaniasis, filariasis, and many other diseases. In the 14th century bubonic plague (transmitted by fleas)

killed a fourth of the people in Europe and two-thirds of those in the British Isles. Yellow fever killed millions before it was found to be transmitted by *Aedes* mosquitoes. It infected British troops in the Louisiana Territory in 1741, killing 20,000 of the 27,000 soldiers. In 1802, French troops arrived there but departed after 29,000 of the 33,000 soldiers died of yellow fever. More than 100 epidemics of typhus ravaged civilizations in Europe and Asia, with mortality rates as high as 70 percent. But by far the greatest killer has been malaria, transmitted by *Anopheles* mosquitoes.

In 1945 the goal of eradicating this scourge appeared to be achievable, thanks to DDT. By 1959, the U.S., Europe, portions of the Soviet Union, Chile, and several Caribbean islands were nearly malaria free.³ In 1970 the National Academy of Sciences stated: “To only a few chemicals does man owe as great a debt as to DDT. In little more than two decades DDT has prevented 500 million human deaths due to malaria that would have otherwise have been inevitable.”⁴

Today, however, after the U.S. ban on DDT, there is a global malaria burden of 300 to 500 million cases and 1 to 2.5 million deaths annually,^{5, 6} mostly among young children. Malaria kills an African child every 30 seconds.⁷

Many South American countries suffered more than 90 percent increases in malaria rates after halting DDT use, but Ecuador used DDT again and enjoyed a 61 percent *reduction* in malaria.⁸

Rachel Carson’s *Silent Spring*

On the first page of the book widely credited with launching the environmental movement as well as bringing about the ban on DDT, Rachel Carson wrote: “Dedicated to Dr. Albert Schweitzer, who said ‘Man has lost the capacity to foresee and forestall. He will end by destroying the earth’.”⁹ She surely knew that he was referring to atomic warfare, but she implied that he meant there were deadly hazards from chemicals such as DDT. Because I had already found a great many untruths in her book, I obtained a copy of Dr. Schweitzer’s autobiography, to see whether he even mentioned DDT. He wrote: “How much labor and waste of time these wicked insects do cause, but a ray of hope, in the use of DDT, is now held out to us.”¹⁰

Effects of Pesticides on Human Beings

Many allegations have been made about the harmful effects of pesticides in general, and DDT in particular, on human health. Even statements about the amount actually ingested by human beings have been dramatically false.

On May 15, 1975, the U.S. Environmental Protection Agency (EPA) released a report claiming that people in the United States were ingesting 15 milligrams of DDT every day. In response to a letter stating that this was obviously untrue, an EPA official responded: "You are correct in stating that EPA's DDT report erred on human dietary uptake. The correct figure should have been 15 *micrograms* per day, instead of 15 *milligrams* per day" (Laurence O'Neill, personal communication, Sept. 11, 1975). He stated that "We will make every effort to rectify the erroneous figures with the news media." Indeed, the EPA did issue a correction stating that the actual number was a thousand times less than that given in their report.¹¹

Human volunteers in Georgia ingested up to 35 milligrams daily, for nearly two years, and did not experience any difficulties then or later.¹² Workers in the Montrose Chemical Company had 1,300 man-years of exposure, and there was never any case of cancer during 19 years of continuous exposure to about 17 mg/man/day.¹³ Concerns were sometimes raised about possible carcinogenic effects of DDT, but instead its metabolites were often found to be *anti*-carcinogenic, significantly reducing tumors in rats. DDT ingestion induces hepatic microsomal enzymes, which destroy carcinogenic aflatoxins and thereby inhibit tumors.^{15, 16}

After an 80-day hearing in 1972 on the potential for carcinogenicity, the EPA concluded that "DDT is not a carcinogenic hazard for man."¹⁷ Nevertheless, EPA Administrator William Ruckelshaus banned DDT two months later, stating that "DDT poses a carcinogenic risk" to humans.³ The primary evidence used to support his assertion was two animal studies. The first was challenged because it was not replicated by other workers using similar dosages and because the findings might have resulted from food contaminated with aflatoxin. The second study, which used a nearly lethal dose, reported hepatomas in 32 percent of the experimental group compared to 4 percent of the control group. However, the tumors were not shown to be malignant, and the litters were not distributed randomly.³

The Effect of DDT on Birds

Many anti-DDT activists alleged that DDT was killing birds or causing them to produce thin-shelled eggs. Some extremists even wrote that because of DDT "birds dropped from the sky, dead."¹⁸ Others said that "birds were falling out of trees by the thousands."¹⁹ No such tragedies actually occurred, not even to a few birds. It was easy to test such claims of toxicity by simply feeding known quantities of DDT to caged birds. Even extreme amounts of DDT in the food did not seriously poison birds.

Rachel Carson declared that "like the robin, another American bird, [the Bald Eagle] seems to be on the verge of extinction."⁹ That same year Roger Tory Peterson, America's greatest ornithologist, wrote that the robin was "the most abundant bird in North America." There is no doubt as to which writer was correct!²⁰

During the "DDT Years," the Audubon Christmas Bird Counts published the numbers seen per observer in 1941 (pre-DDT)²¹ and 1960 (after peak use of DDT).²² The actual numbers seen increased

from 90 birds seen per observer in 1941 to 971 birds seen per observer in 1960.²³

Similarly, the counts of raptorial birds migrating over Hawk Mountain, Pennsylvania, indicated that there were many more hawks there during the "DDT years" than previously. The numbers counted there increased from 9,291 in 1946 (before much DDT was used) to 13,616 in 1963 and 29,765 in 1968, after 15 years of heavy DDT use.²⁴

In Massachusetts, herring gulls on Tern Island increased from 2,000 pairs in 1940 (before DDT) to 35,000 pairs by 1970, before DDT was banned. Gulls were on the state's list of "protected sea birds," but the Audubon Society was permitted to poison 30,000 of them there. William Drury of the Society said that killing those 30,000 gulls was "kind of like weeding a garden."²⁵

On Funk Island, in the north Atlantic, the gannets increased from 200 pairs in 1945 (when DDT use began) to 2,000 pairs in 1958, and 3,000 pairs by 1971 (before DDT was banned). Murres there increased from 15,000 pairs in 1945 to 150,000 pairs in 1958 to 1.5 million by 1971.²⁶

Effects of DDT on Eggshells

The alleged thinning of eggshells by DDT in the diet was effective propaganda; however, actual feeding experiments proved that there was very little, if any, correlation between DDT levels and shell thickness. Thin shells may result when birds are exposed to fear, restraint, mercury, lead, parathion, or other agents, or when deprived of adequate calcium, phosphorus, Vitamin D, light, calories, or water.²⁷⁻²⁹ While quail fed a diet containing 2 percent calcium produced thick shells, a calcium content of only 1 percent resulted in shells 9 percent thinner than normal.³⁰ In the presence of lead, shells were 14 percent thinner, and with mercury, 8 percent thinner.³¹

Bitman and coworkers demonstrated eggshell thinning with DDT by reducing calcium levels to 0.56 percent from the normal 2.5 percent.³² After this work was exposed as anti-DDT propaganda, Bitman continued his work for another year. Instead of the calcium-deficient diets, however, he fed the quail 2.7 percent calcium in their food. The shells they produced were not thinned at all by the DDT. Unfortunately, the editor of *Science* refused to publish the results of that later research. Editor Philip Abelson had already told Dr. Thomas Jukes of the University of California in Berkeley that *Science* would never publish anything that was not antagonistic toward DDT (T. Jukes, personal communication). Bitman therefore had to publish the results of his legitimate feeding experiments in an obscure specialty journal,³³ and many readers of *Science* continued to believe that DDT could cause birds to lay thin-shelled eggs.

Did DDT Endanger Brown Pelicans?

In 1918 T. G. Pearson and Robert Allen estimated that there were 65,000 brown pelicans along the 1,500-mile Gulf of Mexico coastline.³⁴ In 1934, after he became president of the National

Audubon Society but many years before DDT was used, Allen repeated that Gulf survey and found an 82 percent decrease in pelicans. He saw only 200 pelicans in Texas, and practically none in Louisiana.³⁵

In 1971, Robert Finley of the U.S. Fish and Wildlife Service presented testimony to the California Water Quality Control Board in Los Angeles, asserting that “a population of over 50,000 brown pelicans has all but disappeared from the Gulf Coast of Texas and Louisiana since 1961.”³⁶ This figure had been published elsewhere;³⁷ however, since the pelicans were known to have been very scarce there in 1959, an increase to 50,000 by 1961 would have been impossible!³⁸ I called Finley and questioned his figures. He responded by letter on Mar. 29, 1971, stating: “Although the reports are sketchy, Jim Keith and I both feel that the estimate of 50,000 is not unreasonably high.” On August 2, 1971, Finley wrote to Congressman W. R. Poage (before whom I had testified earlier about Finley’s erroneous figures), admitting that “the year 1961 was merely a hasty approximation of an unknown time. After reviewing the evidence, I think now that I should have said that 50,000 pelicans disappeared *by* 1961” [instead of his previous claim that they had disappeared *since* 1961]. Both of those statements were incorrect, but the anti-DDT environmental propagandists never corrected them!

In California, brown pelicans had experienced no difficulties during 20 years of heavy use of DDT, but suddenly suffered nesting failures just two months after the great Santa Barbara oil spill surrounded their nesting island (Anacapa) about Jan. 28, 1969.³⁹ Environmentalists, however, blamed only DDT for the nesting failure, and never mentioned that great oil spill! They also concealed the fact that California Fish and Game found that anchovies there contained 17 ppm of lead, which is known to cause severe shell thinning. They collected hundreds of pelican eggs from that colony during the next two summers, and the shells were measured with screw micrometers. (Collecting 74 percent of all the pelican’s eggs for analysis, of course, was obviously harmful to the success of the colony.⁴⁰) After April 2, 1972, I obtained all of those measurements, and found that they clearly revealed *inverse* correlations between DDT residues and shell thicknesses. Some of the thinnest shells were those of eggs with low DDT, and the higher DDT concentrations were often in the thicker-shelled eggs. This was presented to the EPA and to Congress.^{41, 42}

Robert Finley, however, wrote to Poage on August 2, 1971, to criticize my testimony. He told the Congressmen that “there is not a shred of evidence that spilled oil is capable of causing thin-shelled eggs or otherwise affecting bird reproduction.” In response, I cited many references to the contrary.⁴³⁻⁷ Nothing further was heard from Robert Finley.

Purported Anti-Androgenic Effects of DDT

Florida’s Lake Apopka became famous when anti-pesticide propagandists stated that DDT killed fish and caused shortened alligator penises. It was stated that a mere 0.1 nanogram (1 nanogram = 10^{-9} g) of ethinyl estradiol (EE) per liter of water is a

potent estrogen.⁴⁸ W. R. Kelce claimed that DDT was anti-androgenic, based on an experiment in which he gavaged DDT metabolite DDE directly into pregnant female rat stomachs for five days, at a level 200,000 times the average human dietary intake. “The resulting male pups retained their nipples for 13 days,” indicating, Kelce said, “prenatal anti-androgen activity of DDT.”⁴⁹

However, it was reported that “Lake Apopka is a fetid shallow body of water, the state’s most embarrassing pollution problem. Human waste is dumped into the lake from the Winter Garden’s sewage treatment plant,” as well as citrus-processing wastes, agricultural chemicals, and fertilizers. Also, the alligators had been exposed to the birth control chemical EE that was in the sewage water with the urine of women in Winter Garden.⁵⁰ Moreover, it was reported that alligators there were also being killed by a bacterium, *Aeromonas liquifasciens*, which dissolves internal organs of marine animals.⁵¹

It is also worthy of note that the estrogenic potency of naturally occurring plant bioflavonoids relative to 17β -estradiol is 0.001 to 0.0001, whereas for estrogenic pesticides it is about 0.000001. The estrogen equivalent intake of plant bioflavonoids is about 102 μ /day, compared to 2.5×10^{-6} μ /day from estrogenic pesticide residues. Therefore, the estrogen equivalent ingested in natural substances is estimated to be about 40 million times that from estrogenic pesticides.⁵²

DDT in the Environment

DDT was claimed to have dire effects on marine life. Charles Wurster claimed that marine algae died in his tank of seawater because it contained 500 ppb DDT.⁵³ Paul Ehrlich seemed to approve of Wurster’s hoax, for he wrote an article based on it, which many schoolchildren were required to read.⁵⁴ The following year Ehrlich published that same article in England, in a Sphere Book titled *The Year’s Best Science Fiction*—a more appropriate outlet.

Because DDT is only soluble in water at 1.2 ppb, Ehrlich was asked how he could have such high concentrations of DDT in his seawater. He explained that he had added enough *alcohol* to the tanks to obtain the desired concentrations of DDT in the water. Of course, the seas do not contain much alcohol, so what happened in his tanks bore no resemblance to what would happen in unaltered seawater. Not surprisingly, two other scientists had earlier reported that DDT in their tanks of seawater caused no harm to the same species of algae that Wurster used.

It has often been said that DDT persists for decades in the ocean. Researchers at EPA’s Gulf Breeze Laboratory in Louisiana added DDT to seawater in huge submerged containers. They reported that 92 percent of the DDT *and* its metabolites, DDD and DDE, disappeared from the seawater in just 38 days.⁵⁵

At the EPA consolidated hearings on DDT, George Woodwell, testifying under oath, attempted to convince the court that DDT was building up to high levels in the environment. Incredibly, he had an article published in *Science* a month earlier, in which he and his coauthors found that only 11 million pounds of the 6 billion pounds of DDT that had been produced—less than one-thirtieth of a

year's production in the 1960s—could be accounted for in the world's biota. Indeed, they concluded that “most of the DDT produced has either been degraded to innocuousness or sequestered in places where it is not freely available to the biota.”⁵ ⁶

How the EPA Came to Ban DDT

The printed testimony from seven months of hearings on DDT filled 9,300 pages. My impression was that persons chosen to testify often presented very biased reports that were not truthful.

In an interview with reporters for *Business Week*, published on July 8, 1972, George Woodwell said that he was told by EPA lawyers not to mention his article in *Science*, lest his testimony be disallowed. I specifically discussed Woodwell's testimony in a letter to William Ruckelshaus concerning the frequent absence of truthfulness in testimony. Ruckelshaus responded: “Not only did we not tell Dr. Woodwell to avoid making those statements, but he was not our witness and our lawyers did not talk to him at all” (W. Ruckelshaus, personal communication, 1972). I again read Woodwell's testimony to determine whether that was true. The EPA lawyer (Mr. Butler) had stated: “I'd like to call our next witness, Dr. George M. Woodwell.” Notice that Butler said “*our* next witness.”

In his final 113-page decision⁵ ⁷ issued on April 25, 1972, Hearing Examiner Edmund Sweeney wrote: “DDT is not a carcinogenic, mutagenic, or teratogenic hazard to man. The uses under regulations involved here do not have a deleterious effect on fresh water fish, estuarine organisms, wild birds, or other wildlife...and...there is a present need for essential uses of DDT.”

This decision, however, was overruled by EPA Administrator William Ruckelshaus, who never attended a single day of the seven months of DDT hearings. In his 40-page Final Opinion, handed down on June 2, 1972, he omitted most scientific data, misnamed the major chemicals involved, and proposed that farmers “should use organophosphates, like carbaryl, instead.” (Carbaryl is *not* an organophosphate). He also recommended substituting parathion, a very deadly chemical, for DDT.⁵ ⁸ He later wrote that “in such decisions the ultimate judgement remains political” (W. Ruckelshaus, letter to American Farm Bureau President Allan Grant, April 26, 1979).

The Effect on Science

The procedure for banning DDT reflected the method described by Stanford biology professor Stephen Schneider, who appeared on the scene during fraudulent anti-pesticide debates, predicting grave environmental harm. In a widely quoted statement ⁵ ⁹ to Jonathan Schell in a 1989 article in *Discover*, he explained: “We need to get loads of media coverage, so we have to offer up scary scenarios and make dramatic statements. Each of us has to decide what the right balance is between being effective and being honest.” Schneider has objected to the omission of the last line, “I hope that means being both.”⁶ ⁰

Schneider's “double ethical bind” is the dilemma of scientists involved in advocacy of public policy, particularly that based on the

“precautionary principle.” The remote prospect of an infinite hypothetical harm justifies drastic, urgent intervention, in this view. As Jonathan Schell wrote: “Scientists should disavow the certainty and precision that they normally insist on. There are perils that we can be certain of avoiding only at the cost of never knowing with certainty that they were real.”⁶ ¹

“Forecasting environmental disasters often requires taking a value-laden leap of faith beyond the present state of knowledge,” writes Jocelyn Kaiser.⁶ ² Thus, scientist activists lead a “double life,” imperiling the credibility of science.

Balancing the Good of Humanity

The balance sought by environmental activists is not one of costs and benefits to humanity. Rather, they balance the needs of humanity against the needs of the Planet and the Biosphere in general, as they perceive them. One measure of planetary health is the viability of species. The extinction of any species is a cosmic tragedy, and huge numbers of species are allegedly threatened.

Paul Ehrlich and E.O. Wilson wrote that there is “a massive extinction rate caused by human activity, which threatens the aesthetic quality of the world.” They predicted that “thousands of species will become extinct each year, before they have even been discovered”⁶³—in spite of the fact that Ehrlich himself said that only three species of forest birds became extinct during all of the “destruction” (his word) of eastern North America.⁶⁴

Other assertions about massive species extinctions include these: Norman Myers estimated that we lose “one species a day” and “most haven't even been identified.” He added: that “The extinction rate will accelerate to one species every hour, by the late 1980s.”⁶⁵ Thomas Lovejoy, formerly of the Smithsonian Institution predicted that “15 to 20% of all species, [or] as many as 1,875,000 species, would become extinct” and “at least ten million species, would be extinct by 2000.”⁶⁶ ⁶ In the Global Report 2000 commissioned by President Jimmy Carter, the range of extinctions was stated as 3 to 10 million species.⁶⁷ ⁷ Former Vice President Al Gore stated that “species of animals and plants are now vanishing *one thousand times faster* than at any time in the past 65 million years”⁶⁸ ⁸ [emphasis in original].

Obviously there can never be any factual basis for such hypothetical suggestions, and no credence can be accorded to predictions which have already been proven to be false. Between 1600 and 1900, the estimated extinction rate of known species was about one every 4 years.⁶⁹ ⁹ Since the endangered species list was established, precisely seven species have been declared extinct in the U.S.⁷⁰ ⁰

In attempting to reach the stated if mostly hypothetical objective of preventing a decrease in nonhuman inhabitants of Earth, environmental activist policies have demonstrably increased the human death rate, primarily by thwarting efforts to control malaria. Could this be the true objective of many activists? Jacques Cousteau stated, “World population must be stabilized and to do that we must eliminate 350,000 people per day.”⁷¹ ¹ This is nearly 128 million people per year, or 1.27 billion people over 10 years. Edwin

J. Cohn of the U.S. Agency for International Development (AID) Office of Policy Development was quoted as saying, with reference to the fecundity of many women in poor tropical countries, "Rather dead than alive and riotously reproducing."^{7 2}

Malaria Control?

Environmentalist Gro Brundtland, Director of the World Health Organization, stated in 2001 that her goal was "to halt half of the malarial mortality by 2010 and half again by 2015."⁷³ Apparently, Brundtland will be content if by 2010 only one child dies of malaria every minute, instead of two children dying every minute as at present.

Currently, no obvious efforts are being made to reduce the numbers of infective mosquito adults or larvae, and neither Brundtland nor any of the dozens of recent malaria researchers have proposed plans to help save human lives by killing mosquitoes or their larvae. Such humane preventive endeavors have not even been mentioned in *Science* in recent years! Instead, hundreds of millions of dollars are devoted to the search for vaccines, which might or might not be effective.

At least two malaria vaccine researchers have been indicted. Dr. Miodrag Ristic received \$3.28 million in grants, but developed nothing. In 1990 he was indicted on four counts and heavily fined, but not imprisoned. Dr. Wasim Siddiqui of the University of Hawaii, who had claimed that his vaccine was almost ready for clinical trials, was accused by the U.S. Inspector General of "an apparent diversion and theft of funds, submission of false claims, and criminal conspiracy." Siddiqui was arrested by Honolulu police, but that very day the Vaccine Research Office of AID awarded him another \$1.65 million "to continue his research." Hawaiian Senator Inouye then announced on live television that if Siddiqui was handed any more federal funds he personally would see to it that the University of Hawaii would never get another grant of federal research money.⁷² Siddiqui served six months of house detention, but the local newspapers reported that he was still receiving his salary of \$92,340 a year, even though not teaching classes.⁷⁴

The malaria protections that were hoped to replace mosquito controls have simply been expensive fantasies. After 25 years, AID's malaria vaccine research project is still proving to be a disaster. In a 6-year effort, during which perhaps 18 million human beings died of malaria, U.S. Navy researchers sequenced the genome of the parasite causing falciparum malaria, which has about 6,000 genes, compared to fewer than 30 in a typical virus. The "breakthrough" was announced at a joint press conference in Washington, D.C., called by *Science* and *Nature*.^{7 5} The genome of the *Anopheles gambiae* vector, which contains nearly 300-million DNA base pairs, has also been sequenced.^{7 6} To date, there is no evidence that knowing the sequences will lead to any methods of controlling malaria transmission.

With no better methods available, past mosquito control programs were terminated. From 1974 to 1977, the U.S. Export-Import Bank financed more than \$3 billion of pesticides, saving millions of human lives. In 1977 environmental groups sued to force

AID to ban exports of DDT, after which many countries could no longer obtain any. The World Bank extended \$165 million dollars to India's malaria sufferers, but specified that no DDT could be used. Madagascar suffered from a similar forced lack of mosquito control. Dozens of other countries, where massive numbers of malaria deaths continue to occur, also cannot receive financial aid unless they agree *not* to control mosquitoes by using DDT. In 1986, the AID issued Regulation 16 Guidelines. Secretary of State George Schultz, relying on that as his authority, telegraphed orders to all embassies, stating: "The U. S. cannot, repeat cannot, participate in programs using any of the following: (1) lindane, (2) BHC, (3) DDT, or (4) dieldrin." Millions of poor natives in tropical countries died as a result, from starvation or from malaria and other insect-transmitted diseases.⁷³ The term "genocide" is used in other contexts to describe such numbers of casualties.

Conclusions

The ban on DDT, founded on erroneous or fraudulent reports and imposed by one powerful bureaucrat, has caused millions of deaths, while sapping the strength and productivity of countless human beings in underdeveloped countries. It is time for an honest appraisal and for immediate deployment of the best currently available means to control insect-borne diseases. This means DDT.

J Gordon Edwards, Ph.D., was Professor Emeritus of Entomology at San Jose State University.

Because of the author's death on July 19, 2004, the final version of this manuscript was prepared for publication and proofread by Jane M. Orient, M.D.

REFERENCES

- 1 Bostanci A. Germany gets in step with scientific misconduct rules. *Science* 2002;296:1778.
- 2 Soulsby EJJ, Harvey WR. Disease transmission by arthropods. *Science* 1972;178:1153-1155.
- 3 Wildavsky A. *But Is It True? A Citizen's Guide to Environmental Health and Safety Issues*. Cambridge, Mass.: Harvard University Press; 1995.
- 4 National Academy of Sciences, Committee on Research in the Committee on Research in the Life Sciences of the Committee on Science and Public Policy. *The Life Sciences*. Washington, D.C.; 1970:432.
- 5 MMWR Editorial Note. Local transmission of *Plasmodium vivax* malaria, Palm Beach County, Florida, 2003. *MMWR* 2003;52(38):908-911.
- 6 USAID. Global health, infectious diseases, malaria. Available at: www.usaid.gov/pop_health/id/malaria/. Accessed October 26, 2003.
- 7 Clark T. Malaria is killing one African child every 30 seconds. *Nature ScienceUpdate*, April 25, 2003. Available at www.nature.com/nsu/030421/030421-12.html. Accessed October 26, 2003.
- 8 Roberts DR, Laughlin LL, Hsueh P, Legters LJ. DDT, global strategies, and a malaria control crisis in South America. *Emerg Infect Dis* 1997;3:295-302.
- 9 Carson R. *Silent Spring*. Boston, Mass.: Houghton Mifflin; 1962: frontispiece.
- 10 Schweitzer A. *Out of My Life and Thought: an Autobiography*. New York, NY: Henry Holt; 1949: 203.
- 11 *Chemical and Engineering News*, Sept. 29, 1975.
- 12 Hayes WJ. The effect of repeated oral doses of DDT in man. *JAMA* 1956;162:890-897.

- ¹³ Laws ER Jr, Curley A, Biros FJ. Men with intensive occupational exposure to DDT. *Arch Environ Health* 1967;15:766-775.
- ¹⁴ Laws ER. Evidence of antitumorigenic effects of DDT. *Arch Environ Health* 1971;23:181-184.
- ¹⁵ Silinskis KC, Okey AB. Aflatoxins inhibited by DDT in diet. *J Natl Cancer Inst* 1975;55:653-657.
- ¹⁶ McLean AE, McLean E. Diet and toxicity. *Br Med Bull* 1969;25:278-281.
- ¹⁷ Edwards JG. Errors in the Ruckelshaus decision to ban DDT. *Congressional Record*, July 24, 1972, pp 11545-11547 [entered into the record by Senator Barry Goldwater].
- ¹⁸ Stickel LF. Birds killed by DDT. *Ann NY Acad Sci* 1971;60:162-171.
- ¹⁹ Wurster C F. As long as it doesn't kill anybody. *Innovation Magazine*, January 1971, pp 1-9.
- ²⁰ Peterson RT. *Life Nature Library*. New York, N.Y.: Time, Inc.; 1962.
- ²¹ The 42nd annual Christmas bird census. *Audubon Magazine* 1942;44(Jan/Feb):1-75.
- ²² Cruikshank AD. The 61st annual Christmas bird census. *Audubon Field Notes* 1961;15:84-300.
- ²³ Marvin PH. Birds on the rise. *Bull Ent Soc Amer* 1964;10(3):184-186.
- ²⁴ Taylor JW. Summaries of Hawk Mountain migrations of raptors: 1934 to 1970. *Hawk Mountain Sanctuary Association Newsletters*.
- ²⁵ Anon. Audubon Society to Poison Gulls. *San Francisco Chronicle*, Apr. 8, 1971.
- ²⁶ Bruemmer F. Massacre on Funk Island. *Animals Magazine*, April 1971, pp 554-555.
- ²⁷ Edwards JG. No effect caused by DDT on birds or their eggshells. *Chemical and Engineering News*, Aug. 16, 1971.
- ²⁸ Romanoff AL, Romanoff AJ. *The Avian Egg*. New York, N.Y.: Wiley & Sons; 1949.
- ²⁹ Romanoff AL, Romanoff AJ. *The Avian Embryo*. New York, N.Y.: Wiley & Sons; 1967.
- ³⁰ Tucker RK. Other pollutants may cause thin egg shells. *Utah Science*, June 1971, pp 47-49.
- ³¹ Tucker RK, Haegele HA. Other pollutants may cause thin eggshells. *Bull Environ Contam Toxicol* 1970;5:191.
- ³² Bitman J, Cecil HC, Fries GF. DDT-induced inhibition of avian shell gland carbonic anhydrase. *Science* 1970;168:594-596.
- ³³ Bitman J, Lillie RJ, Cecil HC, Fries GF. Effect of DDT on reproductive performance of caged leghorns. *Poultry Science* 1971;50:657-659.
- ³⁴ Pearson TG, Allen RP. *Adventures in Bird Protection*. New York, N.Y.: Appleton-Century; 1937.
- ³⁵ Allen RP. Pearson's pelican survey in 1918. *Auk* 1934;52:199.
- ³⁶ Finley RB. Testimony before California Water Quality Control Board, Feb. 20, 1971.
- ³⁷ Keith JO. Transactions of the 35th North American Wildlife Conference, 1970, p 56.
- ³⁸ Edwards JG. Brown pelicans revisited: review of data 1918 to 1982. *Nature Society News*, March 15, 1982.
- ³⁹ Jehl JR. Is 30 million years long enough? *Pacific Discovery*, Jan/Feb 1970, pp 16-24.
- ⁴⁰ Hazeltine WE. Testimony before Portland EPA hearings, Jan. 14, 1978.
- ⁴¹ Switzer B. Transcript of EPA Consolidated Hearings; 1972;8212-8236.
- ⁴² Edwards JG. Birds not seriously affected by DDT. Hearings before Committee on Agriculture, conducted by Congressman W. R. Poage, March 1971, S.N. 90-A, pp 575-594.
- ⁴³ King KA. Oil causes pelican mortality for six weeks after spill. *Bull Environ. Contam Toxicol* 1979;23:800-801.
- ⁴⁴ Hartung R. Oil on eggs reduces hatchability by 68%. *J Wildlife Mgmt* 1979;29: 872-874.
- ⁴⁵ Anon. Oil on parent's feathers causes embryo mortality, *NWF Conservation News*, Oct. 15, 1979.
- ⁴⁶ Dieter MP. Oil on eggshells kills 76 to 98% of the embryos. *Report of Interagency Energy-Environment Research & Development*; 1977:35-42.
- ⁴⁷ Szaro SC. Oil causes kidney nephrosis, pancreatic degeneration, and lipid pneumonia. Proceedings, 42nd North American Wildlife and Natural Resources Conference; 1977:375.
- ⁴⁸ Purdom CE, Hardiman PA, Bye V, et al. Oestrogenic effects of effluent from sewage treatment works. *Chemistry and Ecology* 1994;8:275-285.
- ⁴⁹ Kelce WR, Stone CR, Laws SC, et al. Persistent DDT metabolite p,p'-DDE is a potent androgen receptor antagonist. *Nature* 1995;375:581-585.
- ⁵⁰ *National Observer*, June 21, 1971.
- ⁵¹ *Tampa Tribune*, June 17, 1971.
- ⁵² Agency for Toxic Substances and Disease Registry. Toxicological profile for DDT, DDE, and DDD, September 2002. Available at: www.atsdr.cdc.gov/toxprofiles/tp35-c2.pdf. Accessed: July 24, 2004.
- ⁵³ Wurster CF. DDT reduces photosynthesis by marine phytoplankton. *Science* 1968;159:1474-1475.
- ⁵⁴ Ehrlich PR. Ecocatastrophe. *Ramparts* 1968;3(Sept):24-28.
- ⁵⁵ Wilson AJ, Forester J, Knight J. *USDI Circular 335*; 1970:20.
- ⁵⁶ Woodwell GM, Craig PP, Johnson HA. DDT in the biosphere: where does it go? *Science* 1971;174:1101-1107.
- ⁵⁷ Sweeney EM. EPA Hearing Examiner's recommendations and findings concerning DDT hearings, Apr. 25, 1972 (40 CFR 164.32). Summarized in *Barron's*, May 1, 1972, and *Oregonian*, Apr. 26, 1972.
- ⁵⁸ Ruckelshaus W. Opinion and Order in re: Stevens Industries, Inc., et al. (Consolidated DDT Hearings before the Environmental Protection Agency), I.F.&R. Docket Nos. 63, et al.
- ⁵⁹ Lee DR, Guzzo L. *Trashing the Planet*. Washington, D.C.: Regnery Gateway; 1990:167.
- ⁶⁰ Schneider S. Keeping out of the box. *American Scientist* 2002;90(Nov/Dec):148. Available at: <http://www.americanscientist.org/template/AssetDetail/assetid/14778/>. Accessed: July 8, 2004.
- ⁶¹ Schell J. Our fragile Earth, *Discover*, October, 1987, p 47.
- ⁶² Kaiser J. Taking a stand: ecologists on a mission to save the world. *Science* 2000;287:1188-1192.
- ⁶³ Ehrlich P, Wilson EO. Biodiversity studies: science and public policy. *Science* 1991;253:758-762.
- ⁶⁴ *San Francisco Chronicle*, May 21, 1993.
- ⁶⁵ Myers N. *The Sinking Ark: A New Look at the Problem of Disappearing Species*. Clifton, N.J.: Reader's Digest Young Families; 1979.
- ⁶⁶ Lovejoy T. The math of extinction. *Audubon*, November 1982, pp 18-21.
- ⁶⁷ U.S. Council on Environmental Quality, U.S. Department of State. The Global 2000 Report to the President. Washington, D.C.: U.S. Government Printing Office; 1981.
- ⁶⁸ Gore A. *Earth in the Balance*. New York, N.Y., Plume Books; 1993:23.
- ⁶⁹ Simon JL, Kahn H. *The Resourceful Earth: A Response to "Global 2000"*. New York, N.Y.: Basil Blackwell; 1984.
- ⁷⁰ Bailey R. Science and public policy: Our man in science goes to Congress. *Reasononline*, Feb. 4, 2004.
- ⁷¹ Elnadi B, Rifaat A. Interview with Jacques-Yves Cousteau. *UNESCO Courier*, November 1991, p 13.
- ⁷² Desowitz RS. *Malaria Capers*. New York, N.Y.: W.W. Norton; 1991.
- ⁷³ Edwards JG. Mosquitoes, DDT, and human health. *21st Century Science and Technology* 2002;15(3):16-32.
- ⁷⁴ Anon. Scientist accused of theft retains post. *Science* 1993;260:1415.
- ⁷⁵ Davis D. Navy malaria researchers acclaimed for medical breakthrough. *Navy newsstand*, Oct. 3, 2002.
- ⁷⁶ Holt RA, Subramanian GM, Halpern A, et al. The genome sequence of the malaria mosquito *Anopheles gambiae*. *Science* 2002;298:129-149.

