Day 21: Smith & Clancey 383-409

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FURTHER READING

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CHAPTER
11

The Pest War: The Shifting Use and Meaning of Insecticides, 1940–1990

DDT, the first of the modern insecticides, was one of the "secret weapons" contributing to Allied victory in World War II. The military used it for disease prevention. After 1945, DDT was released for civilian use, but under the banner of "war on insect enemies." By the 1950s, insecticide use had become linked to farming and food production, but in the early 1960s, DDT and other insecticides took on a radically new meaning—as poisons that were potentially destroying plant, animal, and human life, while having relatively little effect on insects. DDT was banned in the United States in 1972, but other powerful insecticides continued to be developed and used here and abroad. In Mexico and other developing countries, insecticides became bound up with "modernization" and international trade.

We have seen how technologies can change meanings, and meanings can change technologies. But the story of DDT, and chemical insecticides generally, presents an extreme and compelling case. The implications of believing or not believing claims about insecticides were presented as having enormous consequences—winning the war, feeding the planet, poisoning the planet, sustaining life or destroying it. The technological system, or network, in which insecticides were imbedded grew to be enormously complex: the U.S. government, large public and private research laboratories, small farmers, individual suburban homeowners, starving or disease-ridden people, birds, salmon, vegetables, and the soil. How one described this technological network—what elements were included or left out—or where one resided in the "food chain" became crucial to one's position on insecticide use.

The "pest war," as the insecticide project was described in a 1974 book, was also propelled by metaphor. The designation of particular insects as "pests" had a cultural dimension, as did the use of "war" and other military terms to frame how insecticides should be used. Increased food production in parts of Asia and Africa, associated with the rising use of insecticides, was called the "green revolution." Did these and other words affect how the technology—the network constructed around was out of reach for the American middle classes, but the emperor's mass-produced coach by Fisher beckoned consumers to enter its fantasy world through the illusion of a custom-made body; something a Ford could not. Most importantly, the emphasis on comfort, luxury and safety aimed to appeal to women.

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DOCUMENTS

The authors of nearly all the documents that follow were either scientists or claimed to be speaking in the name of science. Is there an objective "scientific voice" we can rely on to resolve this debate? Does science have an "inside" and an "outside"?

The first document is a press release by the Geigy Company, the Swiss-based developer of DDT, describing the chemical's early manufacture and use in World War II. The text, approved by U.S. army censors, was presented by Geigy at a press conference in May 1944. The second selection is from *Silent Spring* by Rachel Carson, a biologist with the U.S. Fish and Wildlife Service for sixteen years. First published in 1962, Carson's book became a bestseller and a landmark in public concern about insecticides. *Silent Spring* was not universally well received, however. In 1966, for example, it was criticized at length in the fourth selection, from *That We May Live*, by U.S. Congressman Jamie Whitten of Mississippi. The fifth document, from the textbook *The Pest War* (1974) reaffirms the importance of insecticides a decade after Carson's book.

The sixth selection, by computer scientists Roger Weinberg and Ronald Morgan of Kansas State University, is from a chapter entitled "Ecological Problems" in *Computers and the Problems of Society* (1972). It proposes that computers mediate between farmers and the world environment. The seventh selection is from an article by Dr. Rod MacRae et al., "Agricultural Science and Sustainable Agriculture," from the journal *Biological Agriculture and Horticulture* (1989), which presents the case for non–pesticide-based, or "sustainable," agriculture.

"Now It Can Be Told" (Geigy Company Press Release), 1944

The True Story of DDT, Which Alleviated The Typhus Epidemic in Italy; Amazing Preventive Possibilities in Other Fields; Tremendous Benefits to Agriculture; Scientists Do 8 Years' Research in 2; End of Possibilities Not in Sight.

A chemical formula which lay dormant for almost seventy years in a dusty volume of "Berichte der Chemischen Gesellschaft" (the Reports of the German Chemical Society) has suddenly come to life as the progenitor of a spectacular series of insecticidal compositions that seem destined to achieve in preventive medicine an effectiveness already likened to that of penicillin and sulfa drugs in the curative field.

Apart from their sensational preventive properties, dramatically demonstrated in the Army's virtual conquest of typhus, the compositions, in results already attained and in hopes induced by current tests, encourage the belief that they will bring about an economic revolution in the field of agriculture by crops saved from the scourge of insect pests.

When the Geigy patent application was filed in Washington, the military authorities, having come upon a potential major weapon, clamped down a firm secrecy order which had prevented, until last summer, the revelation of any phase of the amazing developments involved. Now, Geigy Company Inc., New York, is able to disclose some of the major aspects of a remarkable discovery. . . .

. . . In 1939 the potato crop of Switzerland was seriously threatened by the imported (from America) Colorado Potato Beetle. Geigy made available to the Swiss entomologist, Dr. R. Wiesmann, a composition carrying the designation "Experiment #G1750" which was later called "Gesarol." Dr. Wiesmann conducted experiments in the Swiss Federal Experimental Agricultural Station at Waederswil and confirmed Geigy's results which culminated in the control of the destructive Potato Beetle. Shortages of the accepted insecticides, arsenates, pyrethrum and rotenone further encouraged the investigations which have revealed DDT compositions as the outstanding development in the insecticide field for many years. . . .

When the United States entered the War it became manifest that its uniformed men would be sent to all parts of the world, meeting the menace of typhus and other dread diseases in many infected areas. Geigy in Basle, aware it had the most effective enemy of typhus ever experienced in medical history, informed Major De Jonge, American Military Attache in Berne, in August, 1942, that Neocid, the lousicidal composition of DDT, had proved amazingly effective against the typhus carrying louse, and that it possessed incredible residual potency, an all important factor. . . .

From the materials submitted by Geigy to the U.S. Department of Agriculture, much excitement was created. . . . Thereafter, scores upon scores of the Bureau's experts undertook experiments in experimental stations all over the United States. . . .

ENTOMOLOGICAL INVESTIGATION CONTINUES AT A MADDENING PACE AND IT IS SAFE TO SAY THAT SCIENTIFIC DATA WHICH UNDER NORMAL CONDITIONS WOULD TAKE ALL OF EIGHT YEARS OF EFFORT TO COMPILE WILL BE AVAILABLE IN TWO YEARS. FEW WILL EVER KNOW WHAT SACRIFICES SCIENTISTS THROUGHOUT THIS COUNTRY HAVE MADE OF THEIR TIME AND EFFORT TO HAVE DDT COMPOSITIONS READY FOR THE ARMED FORCES AND THE PUBLIC. . . .

Geigy, in cooperation with the Cincinnati Chemical Works, was largely responsible for the louse powder which conquered the recent typhus epidemic in Naples and Cincinnati Chemical Works has been by far the largest producer of DDT up to this moment. . . .

Other compositions of DDT in emulsion form have been used to impregnate clothing. . . .

Walls and ceilings covered with a Gesarol spray remain deadly to flies for three months. Dairy cattle made nervous by flies have been quieted by sprayings of the compound, an important item when it is realized that a cow's milk productivity is lowered by a pestilence of flies—apart from sanitary considerations. Beef cattle similarly are benefitted. . . .

Tests on dogs and cats have shown that Neocid not only eradicates fleas but also affords subsequent protection for a long time. In ordinary domestic use, the composition has been most efficacious against moths, roaches, bedbugs, silverfish. Beds properly sprayed just once with a DDT composition continue to be 100%

effective even after 300 days against the bed-bug, the bane of some hospitals and institutions.

House owners may also be comforted by assurance of its deadliness to termites. . . .

. . . DDT compositions, Gesarol Sprays and Dusts, are successful against such garden pests as the Japanese Beetle, thrips, tomato fruit worm, plant lice and the three important cabbage worms. . . .

. . . Geigy believes that it has the support of the United States Department of Agriculture in predicting that the general commercial production of Gesarol, when the military needs have been accommodated, will open the way to what may be regarded as a revolution in the economy of agriculture and in the quantity of the world's food output. . . .

The toxicity of Gesarol and Neocid preparations to man and animals is still under investigation by the U.S. Public Health Service, the Food and Drug Administration and the Kettering Laboratory of Applied Physiology of the University of Cincinnati, the last mentioned research being sponsored by Geigy. Research goes on. Indeed, considerable research is still necessary to determine all the possible uses and ineptitudes of DDT compositions. The forms and methods of application, the rates of application and the dosages on specific plants and in specific climates must be settled. Research is proceeding as rapidly as good practice permits.

Enough has been revealed to indicate the possibility of wide application in agriculture, households and in preventive measures against disease-carrying insects to establish the DDT compositions as among the great scientific discoveries of our time.

MANY AUTHORITIES HAVE DECLARED THAT OUT OF THIS WAR HAVE COME THREE MOMENTOUS DISCOVERIES IN CURATIVE AND PREVENTIVE MEDICINE—PLASMA—PENICILLIN—and—DDT.

Eradicating The Japanese Beetle, 1962

RACHEL CARSON

Under the philosophy that now seems to guide our destinies, nothing must get in the way of the man with the spray gun. The incidental victims of his crusade against insects count as nothing; if robins, pheasants, raccoons, cats, or even livestock happen to inhabit the same bit of earth as the target insects and to be hit by the rain of insect-killing poisons no one must protest.

The citizen who wishes to make a fair judgment of the question of wildlife loss is today confronted with a dilemma. On the one hand conservationists and many wildlife biologists assert that the losses have been severe and in some cases even catastrophic. On the other hand the control agencies tend to deny flatly and categorically that such losses have occurred, or that they are of any importance if they have. Which view are we to accept?

The credibility of the witness is of first importance. The professional wildlife biologist on the scene is certainly best qualified to discover and interpret wildlife loss. The entomologist, whose specialty is insects, is not so qualified by training, and is not

From Rachel Carson, *Silent Spring* (Boston: Houghton Mifflin, 1962), pp. 83–89, 95, 141.

psychologically disposed to look for undesirable side effects of his control program. Yet it is the control men in state and federal governments—and of course the chemical manufacturers—who steadfastly deny the facts reported by the biologists and declare they see little evidence of harm to wildlife. Like the priest and the Levite in the biblical story, they choose to pass by on the other side and to see nothing. Even if we charitably explain their denials as due to the shortsightedness of the specialist and the man with an interest this does not mean we must accept them as qualified witnesses. . . .

During the fall of 1959 some 27,000 acres in southeastern Michigan, including numerous suburbs of Detroit, were heavily dusted from the air with pellets of aldrin, one of the most dangerous of all the chlorinated hydrocarbons. The program was conducted by the Michigan Department of Agriculture with the cooperation of the United States Department of Agriculture; its announced purpose was control of the Japanese beetle.

Little need was shown for this drastic and dangerous action. On the contrary, Walter P. Nickell, one of the best-known and best-informed naturalists in the state, who spends much of his time in the field with long periods in southern Michigan every summer, declared: "For more than thirty years, to my direct knowledge, the Japanese beetle has been present in the city of Detroit in small numbers. The numbers have not shown any appreciable increase in all this lapse of years. I have yet to see a single Japanese beetle [in 1959] other than the few caught in Government catch traps in Detroit . . . Everything is being kept so secret that I have not yet been able to obtain any information whatsoever to the effect that they have increased in numbers."

An official release by the state agency merely declared that the beetle had "put in its appearance" in the areas designated for the aerial attack upon it. Despite the lack of justification the program was launched, with the state providing the manpower and supervising the operation, the federal government providing equipment and additional men, and the communities paying for the insecticide.

The Japanese beetle, an insect accidentally imported into the United States, was discovered in New Jersey in 1916, when a few shiny beetles of a metallic green color were seen in a nursery near Riverton. The beetles, at first unrecognized, were finally identified as a common inhabitant of the main islands of Japan. Apparently they had entered the United States on nursery stock imported before restrictions were established in 1912.

From its original point of entrance the Japanese beetle has spread rather widely throughout many of the states east of the Mississippi, where conditions of temperature and rainfall are suitable for it. Each year some outward movement beyond the existing boundaries of its distribution usually takes place. In the eastern areas where the beetles have been longest established, attempts have been made to set up natural controls. Where this has been done, the beetle populations have been kept at relatively low levels, as many records attest.

Despite the record of reasonable control in eastern areas, the midwestern states now on the fringe of the beetle's range have launched an attack worthy of the most deadly enemy instead of only a moderately destructive insect, employing the most dangerous chemicals distributed in a manner that exposes large numbers of people, their domestic animals, and all wildlife to the poison intended for the beetle. As a result these Japanese beetle programs have caused shocking destruction of animal life and have exposed human beings to undeniable hazard. Sections of Michigan, Kentucky, Iowa, Indiana, Illinois, and Missouri are all experiencing a rain of chemicals in the name of beetle control.

The Michigan spraying was one of the first large-scale attacks on the Japanese beetle from the air. The choice of aldrin, one of the deadliest of all chemicals, was not determined by any peculiar suitability for Japanese beetle control, but simply by the wish to save money—aldrin was the cheapest of the compounds available. While the state in its official release to the press acknowledged that aldrin is a "poison," it implied that no harm could come to human beings in the heavily populated areas to which the chemical was applied. (The official answer to the query "What precautions should I take?" was "For you, none.") An official of the Federal Aviation Agency was later quoted in the local press to the effect that "this is a safe operation" and a representative to the Detroit Department of Parks and Recreation added his assurance that "the dust is harmless to humans and will not hurt plants or pets." One must assume that none of these officials had consulted the published and readily available reports of the United States Public Health Service, the Fish and Wildlife Service, and other evidence of the extremely poisonous nature of aldrin.

Acting under the Michigan pest control law which allows the state to spray indiscriminately without notifying or gaining permission of individual landowners, the low-lying planes began to fly over the Detroit area. The city authorities and the Federal Aviation Agency were immediately besieged by calls from worried citizens. After receiving nearly 800 calls in a single hour, the police begged radio and television stations and newspapers to "tell the watchers what they were seeing and advise them it was safe," according to the Detroit *News*. The Federal Aviation Agency's safety officer assured the public that "the planes are carefully supervised" and "are authorized to fly low." In a somewhat mistaken attempt to allay fears, he added that the planes had emergency valves that would allow them to dump their entire load instantaneously. This, fortunately, was not done, but as the planes went about their work the pellets of insecticide fell on beetles and humans alike, showers of "harmless" poison descending on people shopping or going to work and on children out from school for the lunch hour. Housewives swept the granules from porches and sidewalks, where they are said to have "looked like snow." As pointed out later by the Michigan Audubon Society, "In the spaces between shingles on roofs, in eavestroughs, in the cracks in bark and twigs, the little white pellets of aldrin-and-clay, no bigger than a pin head, were lodged by the millions . . . When the snow and rain came, every puddle became a possible death potion."

Within a few days after the dusting operation, the Detroit Audubon Society began receiving calls about the birds. According to the Society's secretary, Mrs. Ann Boyes, "The first indication that the people were concerned about the spray was a call I received on Sunday morning from a woman who reported that coming home from church she saw an alarming number of dead and dying birds. The spraying there had been done on Thursday. She said there were no birds at all flying in the area, that she had found at least a dozen [dead] in her backyard and that the neighbors had found dead squirrels." All other calls received by Mrs. Boyes that day reported "a great many dead birds and no live ones . . . People who had maintained bird feeders said there were no birds at all at their feeders." Birds picked up in a dying condition showed the typical symptoms of insecticide poisoning—tremoring, loss of ability to fly, paralysis, convulsions.

Nor were birds the only forms of life immediately affected. A local veterinarian reported that his office was full of clients with dogs and cats that had suddenly sickened. Cats, who so meticulously groom their coats and lick their paws, seemed to be most affected. Their illness took the form of severe diarrhea, vomiting, and convulsions. The only advice the veterinarian could give his clients was not to let the animals out unnecessarily, or to wash the paws promptly if they did so. (But the chlorinated hydrocarbons cannot be washed even from fruits or vegetables, so little protection could be expected from this measure.)

Despite the insistence of the City–County Health Commissioner that the birds must have been killed by "some other kind of spraying" and that the outbreak of throat and chest irritations that followed the exposure to aldrin must have been due to "something else," the local Health Department received a constant stream of complaints. A prominent Detroit internist was called upon to treat four of his patients within an hour after they had been exposed while watching the planes at work. All had similar symptoms: nausea, vomiting, chills, fever, extreme fatigue, and coughing.

The Detroit experience has been repeated in many other communities as pressure has mounted to combat the Japanese beetle with chemicals. At Blue Island, Illinois, hundreds of dead and dying birds were picked up. Data collected by birdbanders here suggest that 80 per cent of the songbirds were sacrificed. In Joliet, Illinois, some 3000 acres were treated with heptachlor in 1959. According to reports from a local sportsmen's club, the bird population within the treated area was "virtually wiped out." Dead rabbits, muskrats, opossums, and fish were also found in numbers, and one of the local schools made the collection of insecticide-poisoned birds a science project. . . .

These insecticides are not selective poisons; they do not single out the one species of which we desire to be rid. Each of them is used for the simple reason that it is a deadly poison. It therefore poisons all life with which it comes in contact: the cat beloved of some family, the farmer's cattle, the rabbit in the field, and the horned lark out of the sky. . . .

. . . Our attitude toward poisons has undergone a subtle change. Once they were kept in containers marked with skull and crossbones; the infrequent occasions of their use were marked with utmost care that they should come in contact with the target and with nothing else. With the development of the new organic insecticides and the abundance of surplus planes after the Second World War, all this was forgotten. Although today's poisons are more dangerous than any known before, they have amazingly become something to be showered down indiscriminately from the skies. Not only the target insect or plant, but anything—human or nonhuman—within range of the chemical fallout may know the sinister touch of the poison. Not only forests and cultivated fields are sprayed, but towns and cities as well.

"That We May Live"
A Congressman Responds to *Silent Spring,* 1966

JAMIE L. WHITTEN

Pesticides go through extraordinary tests for safety, and except for a rare allergic reaction, poisoning results only from a large exposure such as a suicide attempt or a major accident.

The extraordinary tests for safety that DDT underwent while it was being developed during World War II have generally been forgotten. Not only animals but human volunteers were fed the insecticide. Scientists from the Food and Drug Administration and the Public Health Service, working at the Department of Agriculture Laboratory at Orlando, Florida, gave a man a dose of 500 milligrams (mg) of DDT without ill effect. This was the equivalent of only about 17.5 thousandths of an ounce, but for a chemical of the insect-killing power of DDT it was quite a dose. Later the scientists gave the same man about 27 thousandths of an ounce, again without harm. . . .

On one point experts and would-be experts of every persuasion agree—there is a great need for more research. This is normal; it would be surprising if someone said there were no need for more research. The history of science shows that the process of finding the answers to questions always raises new questions that need to be answered. So under the impetus of *Silent Spring,* the report of the President's Science Advisory Committee, and the Ribicoff hearings, Congress has provided funds for greatly expanded research into the effects of pesticides. This research is under way. Many reports have yet to be published, but there is no indication at this writing that any results will be cause for alarm.

One type of study that was widely urged, for instance, was the "community study" to measure the average exposure to pesticides from people's total environment, not just their food supply. The Public Health Service began ten such studies in 1964, and Department of Agriculture monitoring operations are cooperating with them. Information on the presence of pesticides and the level of residues in people's bodies will be used to estimate the hazard from pesticide exposure. Many other new research projects are examining the effects of pesticides on animals and man. The result is sure to sharpen our knowledge of pesticides and how to use them safely. In the meantime, the knowledge and techniques we have seem quite adequate to protect the health of the nation's citizens.

One of the most effective voices in quieting the fears aroused by vague charges against pesticides has been that of Frederick J. Stare, professor and chairman of the Department of Nutrition, School of Public Health, Harvard University. A recent article by Dr. Stare, whose newspaper column is widely read, is worth reproducing . . . :

> The current hysteria about agricultural chemicals has seeped in under the doorsills of American homes.
>
> A woman recently said to me, "I feel like Lucretia Borgia every time I put dinner on the table. Am I poisoning my family?"

From Jamie L. Whitten, *That We May Live* (Princeton, NJ: Van Nostrand, 1966), pp. 83, 103–105, 109, 111, 133–141.

> That concerned woman, interested primarily in the health and well-being of her family, deserves to have an end put to her confusion about agricultural chemicals, particularly pesticides. Her bafflement stems not from stupidity, but from the claims and counter-claims of self-appointed experts who usually don't know what they're talking about.
>
> They are usually extrapolating to man some findings on birds, bees or fish, or the unfortunate result of some child inhaling or swallowing large quantities of some pesticide. Such findings just don't extend to the use of agricultural chemicals in growing, protecting or preserving of foods.
>
> Let's set aside all arguments about how or why the current controversy started and concentate instead on letting facts speak for themselves.
>
> One irrefutable fact the critics of pesticides have been unable to answer is this true statement: there is not one medically documented instance of ill health in man, not to mention death, that can be attributed to the proper use of pesticides, or even of their improper use as far as ill health from residues on foods. . . .
>
> In spite of this lack of evidence, many people now have the impression that pesticides contaminate our food supply and are harmful, probably lethal. This gap between fact and fancy must be closed or we will do ourselves great harm by allowing disease and famine to rule the earth.
>
> Are pesticides poison? Of course, that's why they work. They are poison to the insects, worms, rats, weeds and other pests against which they are directed. Because of strictly enforced regulations and tolerance levels, however, the hazard to man from pesticide residues on foods is almost nonexistent. They are dangerous if you handle them carelessly or leave them around where small fry may "play house" with them.
>
> You can have full confidence in our foods. They are not full of poisons as some food faddists would have you believe. They are nutritious and the quality is much better than it was a generation ago.
>
> Eat and enjoy them. . . .

My experience in the Yazoo–Mississippi River Delta region has convinced me that the birds there have actually benefited from the use of pesticides because mites, rodents, and other enemies of birds have been destroyed and because the cultivation of more and more land for grain crops has provided the birds with a plentiful food supply. The Delta, as I have described, is intensively treated with pesticides to fight the boll weevil and other pests. On a recent dove-shooting trip there, my companions and I saw literally thousands of birds and hundreds of sportsmen. At the end of the day many thousands of birds were still flying everywhere. . . .

Wildlife populations all over the nation are bigger and healthier than ever, not in spite of pesticides, but in many cases because of them. . . .

Perhaps Miss Carson's mainspring was the age-old desire we all share in varying degrees to recapture the days of one's youth—to be young again with all things as they were, when the sound of birds in springtime brought the keenest pleasure. Miss Carson pictures wonderfully the "good old days" when man was more in tune with other living things, when nature did not need to be controlled to the extent it does today to meet the needs of population growth and world leadership. In this practical world in which we live, however, we must be careful not to let sentiment and nostalgia blind us to the realistic requirements of modern society.

In the first chapter of *Silent Spring,* "Fable For Tomorrow," Miss Carson describes in beautiful and glowing language a delightful make-believe village in a rural setting "where life seemed to live in harmony with its surroundings." The chapter title itself should be sufficient to put an objective reader on notice as to the nature of her story.

Like many Americans, I grew up in such a small rural village. I, too, remember that the grass was green and the birds sang "sweet in the springtime." But my village has changed—mostly for the better. Regardless of sentiment and nostalgia, very few of us would want to return to the inconveniences of those earlier years. A comparison of my village as it was when I was a small boy with what it is today provides a striking example of the progress we have made through scientific discovery. I remember the "good old days," when to walk barefoot along a dusty country road, to drink cool water from a cistern filled with rain caught from the roof, to read lying flat on one's stomach before an open wood fire by the light of a coal oil (kerosene) lamp seemed to represent the utmost pleasure. Then I had time to listen to the singing of the birds. . . .

My village is one in which many people would like to live; but neither I nor they would want to go back to what it was. Above all, I would not want those who have been released from the farm by labor-saving chemicals, machinery, and electricity, who have moved to the city to provide telephones, automobiles, television sets and other consumer goods, to have to return and dig in the ground to grow food. I would much rather remember those "good old days" while watching television in a modern home, than go back to them with the reduced standard of living.

As I ponder over those "old days" I do remember that we burned on one side while nearly freezing on the other before that open fire. The sweltering heat of summer made it practically impossible to be comfortable. The dusty country road in summer covered us with dust on the shortest trip, and our car got "stuck in the mud" in other seasons.

A flyswatter had a short and hard life, and only a few miles away in the Delta or "bottom," mosquito netting was essential in summer. Really, it must have been my youth which made the "old days" seem so good. . . .

Miss Carson goes further in describing her village of fantasy when she says: "A strange blight came over the area. The people became sick . . . the birds were gone . . . the hens brooded but no chicks hatched . . . the roadsides, once so attractive, were lined with brown."

She then says that such a village does not exist but *might!* She should have known that such situations can and do exist in many places around the world. They exist largely in backward countries where man has not learned to make or to use the scientific weapons that have been developed to cope with disease and pestilence. These nations, almost without exception, have no chemical pesticides to fight insects and blight. . . .

Miss Carson had made a contribution to American literature. But she, along with Henry Thoreau and other essayists who have advocated a return to nature and "the simple life," must not lead us into substituting sentiment and nostalgia for scientific data and facts. . . .

I believe all must agree that *Silent Spring,* delightful reading that it is, certainly is not and was never claimed to be a scientific document nor an objective analysis of the chemical-human life relationship. Though we give to it our highest praise for its wonderful prose, for its timely warning, let us move it over from the non-fiction section of the library to the science-fiction section, while we review the facts—in order that we may continue to enjoy the abundant life.

The Pest War (Textbook Introduction), 1974

W. W. FLETCHER

The war against pests is a continuing one that man must fight to ensure his survival. Pests (in particular insects) are our major competitors on earth and for the hundreds of thousands of years of our existence they have kept our numbers low and on occasions they have threatened extinction. Throughout the ages man has lived at a bare subsistence level because of the onslaught of pests and the diseases they carry. It is only in comparatively recent times that this picture has begun to alter as, in certain parts of the world, we have gradually gained the upper hand over pests.

This war story describes some of the battles that have been fought and the continuing guerrilla warfare; the type of enemies we are facing and some of their manoeuvres for survival; the weapons that we have at our command ranging from the rather crude ones of the "bow and arrow" age of pest control to the sophisticated weapons of the present day, including a look into the future of some "secret weapons" that are in the trial stages; the gains that have been made; and some of the devastation which is a concomitant of war. As with all accounts of war there will be differences of opinion on the interpretation of results and situations; on the emphasis that should be laid on certain parts. This book does not claim to be a definitive account of pest control. It is written for the intelligent non-specialist in the field, who wants to know what the war is all about and the implications of it. It is also aimed at intending students of agriculture, horticulture, medicine, biological sciences; and should also serve as a useful introductory text for elementary courses in pest control in colleges and universities.

Indians, DDT, the Illiac IV: Computer Scientists Respond to the Environmental Crisis, 1971

ROGER WEINBERG AND RONALD MORGAN

Two basic religious concepts of the relationship between man and nature have influenced man's actions toward nature.

The first, appearing in both eastern religions and American (Indian) religions, is the oneness of man and nature. It led man to an inefficient but respectful use of his natural resources. . . .

A second contrasting concept, appearing in Judeo-Christian religion, is the duality of man and nature:

"Then God said, 'Let us make man in our image, after our likeness, and let them have dominion over the fish of the sea, and over the birds of the air, and over the cattle, and over all the earth and over every creeping thing that crawls upon the earth." (Genesis v. 10,27)

From W. W. Fletcher, *The Pest War* (New York: John Wiley, 1974), p. ix.

From Roger Weinberg and Ronald E. Morgan, "Ecological Problems," in *Computers and the Problems of Society* (Montvale, NJ: American Federation of Information Processing Societies, 1972), pp. 339–341, 349, 359, 364–380.

This second conception suggested that man would become an exploiter of nature. And he has exploited it during the 19th and 20th centuries in America, changing many productive Indian systems of life: the Oklahoma plains of the Kiowa, rich in grass and buffalo, into a dust bowl; the Washington salmon streams of the Haida into a sequence of DDT-poisoned reservoirs; the British Columbian Kootenay Lake of the Tlinglit, filled with fish, into a recipient for fertilizer. . . .

By 1971, however, man had also developed the computer, a constructive tool with which he could repair some of his past damage, prevent new damage, and even produce improvements in ecological systems. This tool could hold in its memory a model of a grassland, a salmon stream, a woodland pond, the earth's atmosphere, or even the cycling of elements among the animals and plants of the ocean and the land. It could present these models to man, who could then study and destroy the models instead of the actual systems. In so doing man could learn what to do, and what not to do with the real systems. . . .

With the advent of the electronic computer, accompanied by the concept of the ecosystem, man acquired the capability of simulating complex models of his environment and of analyzing both the model and the real world which it represents. . . .

By 1971 man has begun to use the computer to modify his environment to his liking. . . .

Some of these computers, the minicomputers, will be small and cheap, while others, the parallel processing ones, will be powerful and fast. The little minicomputers, smaller than a refrigerator, are binary computers with a selling price of from $4,000–$15,000. . . . Demand and mass production have already brought their cost down to $10,000 for a useful instrument with all necessary input and output (a teletypewriter is all a man needs). . . .

In the next few years, as the "computer on a chip" becomes a commercial reality, "general purpose" microcomputers will become an integral part of instruments, "modems," and terminals. . . .

As man uses his new technology to miniaturize computers, he will simultaneously use it to produce larger and more complex computers such as the Illiac IV. . . .

Proceeding one step further than the Illiac IV, man will use the computer utility, a network of facilities rather than a single computer, a network which the Illiac IV might be but one unit, a network of many memories and processors into which man can tap at any point for his information processing needs. . . .

With the utility, man is developing a system in which the tiny minicomputers with their sensors may serve as eyes, ears, and nose, receiving weather information at a remote Pacific island, partially processing it, passing it on to a larger, mainland computer which serves as a subunit of the brain. The mainlander considers the information it receives and passes on only important information to the gigantic main computer, which ponders the import of the information to the well being of man.

The utility can extend further, to include the moon and planets, transmitting information on waves through space, and enabling man to comprehend the orderly course of the universe.

Man, although only a small part of a large universe, still has the right to survive and to enjoy his life. He has, as Ehrlich (1968) points out, the right to: eat; eat meat; drink pure water; hunt and fish; view natural beauty; breathe clean air; and avoid pesticide poisoning. This impressive list, deceptively short and straightforward, implies planned terrestrial evolution with the big problems it poses philosophically, politically and economically. In order for the rights to have any meaning, man must understand and cope with these problems through social planning and action.

This will certainly entail limiting man's individual freedom. A Kansas farmer is no longer free to spray unlimited amounts of DDT on his wheat. But is his freedom limited? Freedom is illusory; it does not exist apart from society. . . .

Man obtains this leisure by constructing a society in which he controls the total system, human and nonhuman, in order to make each individual more productive in obtaining food and in avoiding danger. Societies use many norms to guide the formation of rules for control. . . . A Kansas farmer can have a terminal to the utility, at which he can ask on Monday, September 14, whether he can plant wheat next October. The computer may say yes, weather will be fine, and not too much wheat is being planted this year. The farmer tells the computer that he does plan to plant wheat. This information goes into a large data base. But the farmer is not committed. The next day he can change his mind, delete the wheat crop from the data base, and ask the computer whether he can plant sorghum. If the computer says he can, then he can tell it that his crop will be sorghum. By allowing rapid interaction between the data base and its users, the utility permits relatively free individual action while adhering to a firmly structured national policy.

Even though the farmer is free to change his mind, he must still obey the computer. If it tells him that too much sorghum is being planted, he cannot plant sorghum. But man is beginning to understand the advantage of limiting his freedom. . . .

The Illiac IV can be used for linear programming, a mathematical technique for allocating the use of limited resources to maximize or minimize a specified objective. A typical problem, under study at the University of Illinois, involves optimizing the output of the agricultural sector of the economy. The problem may involve regions ranging in size from a farm to an entire nation, the solution to a problem being the production of sufficient food to feed a population, or to export to starving nations. The resources which will be managed according to the solution of the problem will include land, labor, machinery, fertilizers, pesticides, herbicides, storage facilities and capital. The Illiac IV is large and fast enough to make feasible the solution of this large and complex problem. . . .

The systems will be useful to an untrained citizen who wants to know the best place for a fishpond, as well as to a sophisticated systems analyst who wants to know the best distribution of wheat fields for feeding starving nations. . . .

In order to [treat the cause of pollution], man should build a system of data acquisition, transmission, storage and processing, and usage. It will yield preventive or a priori controls over existing environmental systems. Unless the general public attitude changes more rapidly than in the past this goal may have to be accomplished through governmental coercion.

The concept of reorganizing the existing government agencies or creating new administrative bodies to better control science and technology is not new. . . .

The quantity of data necessary for the proper surveillance and monitoring of environmental systems will no doubt reach astronomical proportions. But of far greater importance is the quality and reliability of the data collected. The lack of a universal validation technique is compounded by absence of standardized methods, instruments and sampling techniques. The present diversities of purpose, measuring instruments, storage media and format, and analytical techniques make the purposeful integration of raw data an extremely difficult task. The centralization of such data collection, which is presently done by a hodge-podge of local, state, and federal governmental agencies, most of which are not part of the EPA, [Environmental Protection Agency] is going to become a necessity.

Once the raw data is uniformly stored in data banks a decision must be made as to how to make the most efficient use of it at the various levels in the governmental decision making hierarchy. Data generally takes three forms in any management information system: raw data, summarized data, and some form of indexing as to the kind and location of the data. The data, in one of the above forms, must be channelled upward from the local agency to the operating agency to the federal regulatory agency. . . .

If the data were to be stored geographically, it could either be kept at the regional level or at the operating level. At the present time the most logical configuration would seem to be a system utilizing the first method of data transmission with the raw data base increasing up to the operating level, where it could be stored in a categorical form. The data base could then be summarized at this level and sent upward to the appropriate federal regulatory agency in the Environmental Protection Agency, where it could be coordinated.

This coordination involves a jump to system design, a vast task requiring a team of experts from many disciplines. . . . [A]fter the data has been collected and stored at the operating level, interdisciplinary teams of experts from such fields as law, ecology, bioengineering, computer science, etc., should be assembled to decide which data is relevant and should be retrieved. In order to facilitate cooperation and understanding, the universities should begin to train multidisciplinarians at the doctoral level. There is a pressing need for sound ecological training with emphasis on new quantitative techniques. . . .

[T]raining programs should be based on concrete problems, with the interaction of faculty and students from different disciplines working together to find socially acceptable solutions. More specifically, the ecology students should receive a strong background in mathematical modeling and computer simulation. The present models will become larger and more realistic. The scope of these models will increase in detail, and interaction among more disciplines will be necessary in defining and developing them in order to help solve the rising ecological crisis. . . .

The federal regulatory agencies will be able to make recommendations, but without the proper legislation they will be powerless to enforce them. The present judicial system is simply not adapted to a technical civilization. . . .

Unfortunately it is not enough for the United States or any other single nation of the world to exercise environmental control. The global circulation of the air and ocean currents make it necessary that every nation of the world exercise some degree of pollution control. Senator Edmund Muskie has proposed that the United Nations be used as a fulcrum to expedite global monitoring of air, water and land pollutants. By forcing all the nations of the world to file a "detailed statement of intention and estimate of affects before undertaking any action capable of impairing the quality of the natural environment" the United Nations would have its first practical tool "to direct priorities, to avoid wasteful duplication, and to assure comprehensive action." . . .

In order to aid governments as they control society for its own good, the computer scientist must try to achieve the social goals he has set himself—intelligent and limited control of terrestrial evolution. . . .

Man was originally an insignificant hunting animal who had little impact on his environment. Compared to a 1971 urban commuter, he was free. He was free of a morning train schedule, and of the need to impress his boss at a golf course. He was free to establish his own schedule, and to run naked through the woods. He was also free to die before he was thirty-five, to suffer illness without medication, and to starve if a hunt did not net the requisite deer. For this primitive savage, "freedom is just another word for nothing left to lose." (From Me and Bobby McGee, song by Kris Kristofferson.)

Since these early beginnings man has developed powerful technologies that have been applied according to the rules of complex societies. These applications assured man more food and safety than he had ever enjoyed, but also destroyed whole races of animals and plants, segments of the landscape, and often even nations of people. Modern man must coordinate the restrictions imposed by his society in order to utilize the power conferred by his technology. On the one hand, he must compromise individual freedom in order to maximize the output of his world. On the other hand, he must encourage freedom so that society answers the needs of its members. The computer can aid in implementing individual freedom while preserving a unified plan of action.

Sustainable Agriculture, 1989

ROD J. MACRAE, STUART B. HILL, JOHN HENNING, AND GUY R. MEHUYS

Although many different descriptions of sustainable agriculture are available, the following one will be used as a starting point for this paper.

> Sustainable agriculture is a philosophy and system of farming based on a set of values that reflect heightened levels of awareness and empowerment. Efforts to ensure short-term viability are tested against long-term sustainability, and attention to the uniqueness of every operation is considered in relation to ecological and humanistic imperatives and global implications.
>
> It involves benign designs and management procedures that work with natural processes to conserve all resources, minimize waste and environmental impact, prevent problems and promote agroecosystem resilience, self-regulation, evolution and sustained production for the nourishment and fulfilment of all.
>
> In practice such systems have tended to avoid the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives, and instead rely upon crop rotations, crop residues, animal manures, cultivation, and mineral-bearing rocks to maintain soil fertility and productivity, and on natural, cultural and biological controls to control insects, weeds and other pests.

From R. J. MacRae, et al., "Agricultural Science and Sustainable Agriculture: A Review of the Existing Scientific Barriers to Sustainable Food Production and Potential Solutions," *Biological Agriculture and Horticulture* 6 (1989): 174–175, 207–208.

> The potential of this approach, however, goes far beyond its present expression, which has largely been limited to the substitution of environmentally benign products and practices. More significant advances can be expected as a result of developments in the science and art of agroecosystem design and management.

Such a description includes farming systems variously referred to as organic, biological, ecological, agroecological, biodynamic, regenerative, alternative, natural, and permanent. . . .

Many of the new scientific methodologies are being performed by multidisciplinary teams that include people who are not professional scientists. The farmer, and other individuals who are directly involved in the food and agriculture system, are being recognized as having much to contribute to our understanding of ecological processes in agriculture. Farmer associations are being created to perform research. Some investigators even feel that most innovation in sustainable agriculture originates with the farmer. A study of organic farmers in the Midwest U.S.A. found that 62% of them were doing their own research. Brooks & Furtan (1985) have concluded that the higher the level of training and awareness, the more likely farmers are to do their own research, and by our definition, sustainable agriculture requires a high level of awareness. Some organizations have even produced manuals for lay scientists to encourage this interest in home-grown research. The potential value of lay science is reflected in the U.S. Congress O.T.A. [Office of Technology Assessment] (1985:5) conclusion that most innovative research is not taking place in the institutions normally associated with research activity.

Some scientists are already working directly with farmers. Known by many names (participatory research, farming systems research, on-farm research ethnoscience), each varying somewhat in approach, these methods have in common a belief that the practitioner has at least as much to contribute to the process of understanding biological systems as does the investigator. These approaches are also concerned with much more than the natural environment in which farming takes place. Sociocultural, economic, and political factors are all considered to be part of the investigation to obtain a more complete understanding of why certain agricultural practices work and others do not. The farmers' objectives as producers are critical to this understanding.

ESSAYS

In the first essay, Edmund Russell presents a detailed history of the development, testing, and early use of DDT during World War II. He cities evidence that certain scientists and military officials had deep concerns about this powerful chemical, but that this "complex" story had little effect on the "simple" story about DDT's benefits. In the second essay, Angus MacIntyre offers a "political economy" of insecticide use grounded in historical narratives about farmers, the economy, World War II, chemical companies, the U.S. Agriculture Department, research scientists, and southern congressmen. Rejecting the idea that insecticide use was a conspiracy orchestrated by chemical companies, he argues that American agriculture was predisposed to accept pesticides and that the chemicals became imbedded in an extensive web of interests.

The last selection is from Angus Wright's *The Death of Ramón González* (1990). Wright briefly describes the political economy of Mexico's Culiacán Valley and then traces a chain of events leading from American supermarkets to the use of a particularly dangerous chemical by valley growers in the late 1980s.

MacIntyre did not have access to Russell's evidence when he published his article. Would this knowledge have changed his conclusions, or are MacIntyre's and Russell's arguments complementary? What is Wrights's explanation of why dangerous technologies proliferate?

Testing Insecticides and Repellents in World War II

EDMUND P. RUSSELL III

This paper focuses on two stories about insecticide safety in World War II. One is the complex story. People in a bewildering variety of institutions conducted tests and made judgments on insecticide safety in World War II. They usually agreed and sometimes disagreed, but they shared a commitment to developing insecticides that would save lives in war. War conditions influenced their perception about what level of danger was acceptable. Many researchers distinguished between "military" and "civilian" criteria. Formerly classified documents reveal that researchers were very concerned about a wide variety of risks associated with insecticides, especially DDT, but that frightening information was often kept secret.

The other is the simple story. This story drew on the complex story, but it contrasted sharply with it. Whereas the complex story featured an ongoing struggle to compare risks and benefits, the simple story emphasized benefits. Risks had little role in public discussion until after a public image of DDT's safety was formed, and questions about safety were swamped by publicity of benefits.

These stories illustrate not only the influence of war on the development of technology, but on the way technology is understood. World War II offered incentives to conduct unprecedented research on insecticide safety before products were released to the public. War also created incentives to increase production and forecast wide civilian benefits. A direct result of this process was the lionization of DDT, which engendered public and professional enthusiasm for chemical control of insects after World War II. The environmental consequences of that enthusiasm were enormous.

This process also had cultural consequences. DDT passed into American iconography as a symbol of unforeseen effects. DDT was developed to save people from disease and starvation, the story goes, and no one knew its risks until the chemical was widely used. It is a good story, but flawed history. Many of the effects of insecticides that Rachel Carson excoriated in *Silent Spring* (1962) were known or suspected before DDT was released for public use at the end of World War II. The popularity of the "unforeseen consequences" version is a testament to the ability of powerful experiences to mold public understanding of technology. Fifty years after the simple story was first told, it still holds center stage.

A specific goal drove development of insecticides by the U.S. government in World War II: military victory. During World War I, louse-borne typhus had killed 2.5 million

From Edmund Russell, "Safe for Whom? Safe for What?: Testing Insecticides and Repellents in World War II" (paper presented at American Society for Environmental History, Pittsburgh, PA, March 4–7, 1993, and edited in November 1997).

people along the eastern front. Another insect-borne disease, malaria, had crippled French and British troops. As the United States mobilized for World War II, planners took these lessons to heart. By one estimate, half the American troops in malaria-infested areas would probably become casualties in the first mosquito season. Insecticides could contribute to victory by killing insects that transmitted typhus and malaria. . . .

In World War II, one of the services' most important allies was the Committee on Medical Research (CMR), an institution created to organize civilian research on military medicine. . . .

The Committee on Medical Research approached military medicine with the same pragmatism as military medical officers. Their commitment to military victory became clear when the committee decided to keep all medical advances secret. The committee, which included a number of medical doctors, reached this decision after some deliberation. They recognized that, as doctors, they were duty bound not to distinguish between friend and foe. However, they also recognized that a new prophylaxis against malaria, for example, might determine the outcome of the war. The committee decided that patriotic obligations overrode professional obligations.

Consequently, research for CMR was classified.

In 1941, the committee's Colonel James Simmons asked the U.S. Department of Agriculture's Bureau of Entomology and Plant Quarantine (BEPQ) to develop proposals to research insect repellents for mosquitoes and insecticides to kill lice. . . .

BEPQ decided to devote its laboratory in Orlando, Florida, to military projects for CMR. Investigations began in April 1942. Researchers in Orlando saw a distinction between their usual civilian research and their new military research. In their final report, researchers recalled: "Investigations that had been conducted prior to that time were largely for the purpose of developing methods of control for a limited number of species under conditions as they exist in peace time. The new type of mobile warfare required methods that could be applied under a variety of conditions and which would be effective against a wide range of insect species."

Not only did Orlando researchers seek technology suited for mobile warfare around the world, but they also needed to find something fast: "The problems were considered to be of an emergency nature and every effort was made to develop control methods within the shortest time possible." Finally, researchers emphasized pragmatism rather than perfection: "In order to develop practical control measures as quickly as possible all research was designed to obtain information that would be of immediate value in providing a satisfactory answer to a problem. Because of this approach, there was little opportunity to carry on studies of an academic or strictly fundamental nature."

At the urging of Colonel W. S. Stone of the surgeon general's office, the Orlando laboratory made louse powders its first priority. . . .

At the same time that researchers scrambled to find an effective lousicide, they also searched for an effective repellent to prevent bites by malaria-carrying mosquitoes. The National Research Council had been coordinating research by industry and foundations since 1940, but nothing satisfactory had been found. The urgency of the project led researchers to lower their standards for safety. National Carbon Company, for example, emphasized that the emergency called for evaluating insect repellents with different criteria from peacetime:

"To simplify our language we shall call a product for general public use a 'civilian repellent' and that for the military forces a 'military repellent.'

"Up to recently we were working on an improved civilian repellent. Now we are working on a military repellent. This shift in goals appears to have a profound effect on the choice of appropriate acceptance standards for some of the physiological tests.

"The alternative to the use of a civilian repellent is never worse than the discomfort of a harmless bite; while, with a military repellent, the alternative to its use may well be the bite of a dangerous insect with resulting prolonged or serious illness. The civilian repellent is merely a 'comfort' product. The military repellent is a disease prevention—sometimes almost a life or death, product. Clearly the military repellent does not call for such meticulous physiological acceptance standards if their adoption excludes an otherwise desirable product. . . .

"We are in a position right now where we must give heed to these general arguments. We are studying the properties of twenty new repellent chemicals whose dry repellent rating ranges from 125 to 265.

"To apply 'civilian' acceptance standards for Tests B and C, 'Primary Skin Irritation' and 'Human Skin Sensitization,' eliminates all but two or three chemicals and those remaining are of low rating. If on the other hand we apply 'military' acceptance standards we *retain* some 14 or 15 chemicals; eight of which have a rating of 200 or better.

"We now plan to use only the 'military' acceptance standards in rejecting products from further consideration." [Emphasis in original]. . . .

The army's concern about finding a product to protect soldiers from malaria immediately was well-grounded. From the surgeon general's point of view, 1942 was the beginning a "disastrous experience" with malaria. After the fall of Corregidor, a fortified island at the mouth of Manila Bay, American and Filipino troops retreated to Bataan, where they surrendered on 9 April 1942. A regimental surgeon described the dismal health of troops: "To give an accurate word-picture of conditions as they actually existed at the time immediately preceding the surrender of our forces on Bataan would tax the descriptive powers of a rhetorical genius, but in simple language, almost every man in Bataan was suffering, not only from the effects of prolonged starvation, but also from one or both of the acute infections that plagued us throughout the campaign, viz, dysentery and malaria." The *New York Times* trumpeted this failure of preventive medicine in a headline: "Troops on Bataan Routed by Malaria."

The experience on Bataan was not unique. In 1942, troops in Latin America suffered a malaria rate of 108.34 cases per 1,000 soldiers per year, compared to a world-wide rate for the U.S. Army of 7.18. In the China-Burma-India theater, the rate by June 1942 was 127. These numbers paled, however, compared to those in the South Pacific. The first malaria outbreak among allied troops occurred on Efate, a small island in the New Hebrides occupied in March 1942. By April, the malaria rate was 2,678 cases per 1,000 soldiers per annum. On Guadalcanal, the malaria rate was 1,664 per 1,000 per annum in October 1942, and 1,781 in November. Rates in some units were as high as 4,000 per 1,000 soldiers per annum. On average, every soldier in those hard-hit units came down with malaria four times a year. . . .

Just as supplies of insecticides became critical, a savior appeared in the form of a simple molecule called dichlorodiphenyltrichloroethane, or DDT. DDT, which looked so miraculous in 1943, had appeared utterly uninteresting in the United States just two years before. Geigy Company of Switzerland discovered DDT's insecticidal properties in 1939 and offered the substance to its U.S. subsidiary in 1941. The subsidiary declined to market it. DDT's only known use was for the Colorado potato beetle, which the subsidiary considered well-controlled with lead arsenate.

The demands of war led Geigy's parent company in Switzerland to try again. War opened a market for killing lice that had not existed before, led to free research and development by the United States government, and made synthetics attractive because imports of botanical insecticides were cut off. It also broke down barriers between BEPQ and industry. War-induced shortage of rotenone and pyrethrum had led the bureau to revise its policy on testing proprietary products. If a company presented sufficient evidence, the bureau would test insecticides for agricultural use. Plus, the Orlando laboratory tested every sample it could find, from whatever source and no matter how unproven, for military use. In October 1942, Geigy gave BEPQ some Swiss reports showing that DDT was not only efficacious against insects, but "relatively non-toxic to man and animals." It sent a sample of DDT (then known as Gesarol) on 3 November 1942.

The Orlando laboratory found DDT "had insecticidal properties possessed by no other synthetic organic chemical known at that time. The material showed a high degree of toxicity to lice, and the toxic action persisted for an unusually long time." The powder killed lice for at least three weeks, which was "the type of material we were looking for." In February 1943, the lab tested DDT on mosquito larvae. Researchers were thrilled to find that DDT killed *Anopheles* almost completely "at the extremely low concentration of 1 part of DDT to 100 million parts of water. . . . There was reason for real optimism: here was a material exactly 100 times as toxic to mosquito larvae as was phenothiazine, the most effective synthetic organic larvicide previously known." Further tests showed DDT was 25 times as effective as Paris green, the standard anopheline larvicide.

. . . Geigy officials said they could make DDT in the United States. Members of BEPQ and the Quartermaster Corps visited Geigy's plant in Norwood, Ohio, and "encouraged them to proceed as rapidly as possible with the production of DDT." Pilot plant production began in May 1943.

That same month BEPQ recommended, and the army adopted, DDT as a louse powder. . . .

Still unanswered, however, was the question of DDT's safety. No large-scale experiments on humans had been conducted, so planners accorded great weight to the experience of subjects and researchers in Orlando. A report from 11 May noted: "there are men at Orlando who have been in intermittent contact with neocid [DDT] (and some of whom have worn impregnated garments) for some three months, and who give no evidence of sensitization, or of toxic symptoms." Apparently referring to tests by the FDA, the report also said that DDT "is harmless if applied wet or dry for 24 hours to intact or abraded skin of rabbits."

Would solvents affect toxicity? M. I. Smith of the National Institute of Health undertook experiments focusing on absorption through the skin. In May 1943, he

reported that painting 5% solution of DDT in kerosene on the shaved bellies of rabbits led to tremors and paralysis. Other experiments showed that 25% DDT solution in dibutyl phthalate killed rabbits.

Feeding tests also produced frightening results. The army's James Simmons later recalled, "The preliminary safety tests, made with full strength DDT, had been somewhat alarming. When eaten in relatively large amounts by guinea pigs, rabbits and other laboratory animals, it caused nervousness, convulsions or death, depending on the size of the dose." But the army was desperate for an insecticide, so, Simmons remembered, "in spite of the earlier rather startling toxicity reports we had asked our people to start a limited manufacturing program [of DDT.]" . . .

While researchers scrambled to assess toxicity, DDT production soared. Geigy expected to make 1000 pounds of DDT per week in May and 10,000 pounds a week in July, which roughly equaled the world production of pyrethrum. The army began contacting other firms to interest them in manufacturing DDT.

In July 1943, the National Research Council held a conference to review the status of insecticides and repellents. The FDA's H. O. Calvery reiterated that DDT killed test animals when ingested, but he felt that "the hazards must be weighed against the great advantages of the materials." Calvery accepted the use of DDT on clothing and in powder form for use against lice, because little DDT in those forms appeared to be absorbed. But DDT should not, Calvery warned, come into contact with skin when dissolved in solvents, because that would greatly facilitate absorption into the body. By this time, Geigy was producing enough DDT in Ohio to find its supply of materials (especially chloral hydrate) a bottleneck in production. The army asked the War Production Board to intervene to provide Geigy with more raw materials.

In August 1943, Calvery reported on DDT's chronic toxicity. Calvery rubbed rabbits with varying amounts of DDT ointments daily. . . .

Calvery's summary was grim: "DDT in solution is absorbed by the intact skin and is very toxic upon absorption. . . . Doses which do not cause death within the first week allow the animals to make an apparent recovery. However, such animals become subject to secondary infections and die from other causes due to lowered resistance. . . ."

At NIH [National Institute of Health], on the other hand, [Dr. P. A.] Neal's team was far less alarmed. Their inhalation studies found that species varied in their response. Mice often died, while monkeys "showed no signs or symptoms of any toxic action." Neal tested aerosols on two humans "without showing evidence of subjective or objective signs of Gesarol [DDT] poisoning." When Neal exposed dogs to "Massive Doses of Gesarol Dust," he found it "caused neither toxic effects nor definite pathological changes." He suggested that "*the inhalation of fine Gesarol powder or the ingestion of powdered Gesarol without solvent is not as toxic as might be suspected* [emphasis in original]."

By October 1943, Neal and his colleagues were confident that DDT "posed no serious health hazards." While acknowledging DDT's "inherent toxicity," they concluded that Gesarol was safe when used as an aerosol, dust, or mist. In aerosol tests, only mice had shown symptoms of poisoning. DDT dusts seemed insoluble, plus particles were so large they lodged in the uppermost sections of the respiratory tract rather than in alveolar spaces. Finally, sprays were probably safe because they would expose people to "temporary and comparatively moderate exposure." Rabbits had survived smaller doses without showing signs of poisoning. The team warned, however, that "ingestion of massive doses of Gesarol will be toxic," and cautioned against "heavy contamination of food."

On 27 October 1943, Surgeon General Thomas Parran distributed the Neal team's report with his concurrence that DDT, in the forms tested, "offered no serious health hazards." The army's James Simmons exulted at this "final assurance that the material is not dangerous for use under the conditions which we had selected." . . .

Although the army had decided in May 1943 to adopt DDT louse powder, it had questions about solvent forms. Neal's report freed the army to use DDT for all insects, especially mosquitoes. Simmons "immediately started asking for a great expansion in production. This meant mobilizing the industrial manufacturers, with all of the complex legal machinery required to do so." The pressure to increase production was intense. Medical officers overseas fretted that DDT would not be available in time to stop typhus epidemics, which usually came in winter. In November, one officer complained, "[W]e have gone hook, line and sinker for D.D.T. for disinfestation of the civilian population in the Balkans and all militarily employed civilian labor, and it seems to me that our scheme is going to fall down very badly unless something can be done to get us the amounts wanted."

The rapid expansion of production came through just in time for DDT to play a role in one of the most famous events in the history of military medicine. During the winter of 1943–1944, typhus appeared in bombed-out Naples. Among other measures, Allied health organizations dusted over a million civilians with louse powder. They began with pyrethrum and rotenone powders, which broke the back of the epidemic. Then DDT powder arrived and permitted far wider dusting. This event marked the first time a typhus epidemic was halted in wintertime, and DDT received much of the credit. It was the new wonder weapon of public health. . . .

Until this time, strict secrecy had surrounded the insecticide projects. Now the army decided to go public. James Simmons, among others, began promising that DDT would solve civilian as well as military problems. For the first six months, news of DDT featured only its spectacular benefits with little hint of questions about its risks.

In December 1943, Simmons told the Associated Press that "The wartime development of effective repellents and insecticides will probably constitute the biggest contribution of military medicine to the civilian population after the war—a contribution even greater than blood plasma." He said a secret new insecticide "might be spread like a veneer on walls to make rooms fly-proof." . . .

In March 1944, the same month that the *Chicago Tribune* touted DDT as "harmless," the army summarized its knowledge about safety in a guide for soldiers. Its view was more complicated than the *Tribune*'s. DDT dust appeared to pose negligible risk, but "Since toxic doses of DDT can be absorbed through the skin from oil solutions, care must be taken to prevent continuous contact." It also noted that DDT should be kept away from food because "DDT is poisonous when ingested."

H. O. Calvery was especially concerned about chronic toxicity of DDT including the effects of small amounts eaten over long periods of time. On 30 May 1944, he reported: "Chronic and subacute feeding experiments show that small amounts of DDT in the diet will produce toxicity in small animals, and that the safe chronic level could be very low indeed. Chronic experiments extended over periods of time longer than 35 weeks will be necessary before chronic toxicity of this compound can be adequately assessed."

About the same time, the army approved release of publicity about DDT's remarkable powers that said little about safety tests. For example, the army gave permission for Geigy Company to issue a press release titled "NOW IT CAN BE TOLD." Its first ten pages were filled with news of DDT's development and benefits. On page eleven, one paragraph mentioned that the toxicity of DDT was under investigation at several institutions and that "Research is proceeding as rapidly as good practice permits." In context, it sounded as though there was little news about toxicity to report.

Within the chemical industry, however, rumors began to circulate about DDT's toxicity even while the army kept all reports classified. In July 1944, a trade journal reported that the National Research Council killed a report on DDT toxicity scheduled for an insecticide association meeting: "Enough data was presented in another paper, however, and in over-the-fence whispers, to indicate that there is a certain amount of fire behind the DDT toxicity smoke." One manufacturer was said to be labeling the product "poison."

Worries about toxicity concerns soon found print in more widely-read publications. In July 1944, the Surgeon General's Office was shaken by a report in the *Washington Post*. The article began, "DDT is dynamite for insects, but the Agriculture Department isn't sure some of its magic may not be harmful to man, beast and some insects such as the honey bee." The article said entomologists were worried that DDT might injure plants, and that DDT residues on fruits and vegetables would accumulate in people "to the point of eventual generous poisoning."

A member of the Surgeon General's Office telephoned W. E. Dove of BEPQ. Dove confirmed the concerns in the story while emphasizing that these were questions that needed to be answered. General Stanhope Bayne-Jones of the Preventive Medicine Service reflected that men using DDT dusts showed no sign of chronic poisoning. He noted, "Another statement made verbally by Dr. Dove to Col. Ahnfeldt—I am told—is that this 'scare' was thrown out to keep the farmers quiet while DDT is so scarce."

July 1944 was also the month that researchers began to publish their data on DDT toxicity in professional journals. M. I. Smith and two colleagues at NIH described DDT's effects on animal nerve cells, spinal cords, brains, muscles, kidneys, and especially livers in two articles in *Public Health Reports*.

Science News Letter took notice of the technical articles by Smith et al. It repeated their conclusion: "The toxicity of DDT combined with its cumulative action and absorbability from the skin places a definite health hazard on its use." . . .

Persistence, the trait that made DDT ideal as an insecticide, was also a source of concern. Looking ahead to possible uses of DDT in agriculture, *Science News Letter* said, "[S]cientists would like to know whether the liver or other organs may be seriously damaged by eating it on vegetables and fruits. The amount on each apple or tomato would be small, but in the course of a few years, quite a lot might accumulate in the body from such sources."

By this time, the public had been treated to more than six months of publicity stressing DDT's miraculous safety and efficacy. *Science News Letter* did not reach nearly so many people as did newsreels and newspapers, which had created images of DDT's safety that were not easily erased.

More publications soon followed. H. O. Calvery and his colleagues published their findings in a professional journal in August 1944. They noted that gross pathological changes were "not outstanding in any of the species studied" after being given DDT in various forms. Microscopic pathological changes, however, were common. In five pages of tables, they detailed symptoms for individual animals, with liver lesions being the most common. They warned that feeding experiments showed "small amounts of DDT in the diet will produce toxicity in experimental animals, and that the safe chronic levels would be very low indeed." They said that studies of longer duration would be needed to assess DDT's chronic toxicity.

Meanwhile, Neal found no reason to change his view that DDT was safe. To collect data on the effects of DDT on humans, his team chose to study three men who had been exposed to "extremely great" amounts of DDT while working at the Orlando laboratory. In physical examinations spread over four days, they found that "none of them present definite findings that can be attributed to the toxic action of DDT."

Calvery and Neal brought their results to the entomological community in November 1944, when they addressed the Entomological Society of Washington. Calvery summarized his position as, "More experimentation is needed before we will have clear and full understanding of DDT and the various formulations in which it may be used for insecticidal purposes." Neal, assessing aerosols, "concluded that despite the inherent toxicity, the use of DDT in one to five per cent solutions in 10 per cent cyclohexanone with 85 to 95 per cent 'Freon,' as aerosol, should offer no serious health hazards when used as an insecticide." In December 1944, the *American Journal of Public Health* announced "DDT CONSIDERED SAFE FOR INSECTICIDAL USE." It based its report on a November announcement by Neal. Calvery's concern about other formulations went unmentioned.

The army committee that oversaw insecticide development shared Neal's confidence. It reported in December 1944 that the "possibility of human intoxication was considered slight in the light of the widespread dissemination of instruction as to proper use." The committee did recognize that "an occasional case of intoxication may occur, in which event there is very little known as to effective antidotes."

Unfortunately, soldiers did not always use insecticides in the same manner as Neal. One of DDT's advantages was that it dissolved in almost any organic solvent. The army shipped concentrated DDT to theaters, where soldiers mixed it with whatever solvent was at hand. Although researchers focused their attention on DDT, solvents also posed a hazard. The army found "several cases which had both subjective and objective symptoms resulting from excessive exposure to the vapors or droplets of the solvents used for DDT."

A case in the China-India-Burma theater was typical. The commanding general sent a secret radiogram to Washington in July 1944 announcing that his troops had achieved good results in killing mites by impregnating clothing with DDT in acetylene tetrachloride solution. Impregnation was accomplished "by soaking clothing in a bucket of the solution, wringing out dry and evaporating the acetylene tetrachloride." General Stanhope Bayne-Jones of the Surgeon General's Office fired back this message: "Acetylene tetrachloride more properly known as tetrachlorethane is the most toxic of the halogenated organic solvents . . . this substance must not repeat not be used in open buckets as described . . . but must be employed in closed systems with special precautions to insure against exposure to fumes . . . recommend immediate survey of all pers[ons] who have engaged in process as you have described for signs of liver intoxication or acute central nervous system symptoms." In January 1945, the surgeon general's office suggested that DDT be dissolved in 80 octane gasoline to avoid "the toxicological complications encountered in the use of most solvents."

Although the army threw a tremendous effort into pushing the production of DDT, it expended far less on producing reports about toxicity. When someone in the office of Inter-American Affairs requested information on DDT's toxicity in January 1945, the army replied that it had "never published a comprehensive study" of DDT's safety.

As the end of the war neared and talk of civilian uses for DDT reached fever pitch, the Food and Drug Administration looked for effects of DDT that were of little concern for soldiers. One study, reported in August 1945, showed that DDT accumulated in [the] body fat of dogs. It also appeared in their milk.

The discussion so far has focused on toxicity to humans, which reflects the priority of the army and researchers throughout the war. But as DDT found use as a mosquito larvicide, researchers noticed that DDT could affect a variety of species. In March 1944, the army cautioned its soldiers: "DDT is a toxic agent[. W]hen used at rates recommended in oil or dust the toxic effect is limited to mosq. larvae [sic]. Other animal life that has come in contact with treated areas, such as fish, cattle, fowl, etc. has not been affected. However, if the dose is too heavy fish may be killed, and animals or men using this water for drinking purposes might ingest a toxic dose."

Reports of effects on non-target species tended to come not from medical doctors, who carried out some tests of DDT's efficacy in theaters. They generally came from entomologists and others with broader biological training. Leroy Christenson, an entomologist and captain in the Sanitary Corps, reported in January 1944: "A striking effect of DDT in pools where it was used was its toxicity to all other forms of macroscopic life. Usually the killing effect was a total one with small fish, crabs, and all types of immature insects such as dragon fly, damsel fly, and chironomid (midge) larvae being effected [sic]. Diesel oil without DDT had no ill effect on these types of animals." A British report commented on the same phenomenon: twenty four hours after spraying, researchers found dead prawns, fish, dragon flies, and caterpillars.

Orlando researchers pointed out these problems when they trained military personnel in the use of DDT. Edward S. Hopkins, a major in the Sanitary Corps who studied in Orlando, noted: "One ppm. of DDT emulsion admixed in the water of quiet pools will prevent larvae breeding for about a month. Higher dosage will be fatal to fish life and 2 ppm. is fatal to snakes, toads and frogs."

BEPQ personnel were also concerned about the effect of DDT on beneficial insects. Before World War II, bureau entomologists had stressed the importance of insect predators and parasites for keeping pest insects in check. They had even come to recognize that broad-spectrum insecticides could create pest problems, and DDT was a broad-spectrum insecticide without peer. Tests confirmed that DDT tended to kill most insects, not just target species. In fact, it sometimes killed beneficial parasites more readily than it killed pests. One study found a six-fold increase in aphid infestations in sugar cane plots dusted with DDT. Predators commonly attacked aphids in untreated plots, but they were absent from treated plots. Similarly, fruit trees sprayed with DDT became infested with mites and spiders after lady beetles were killed.

After conducting experiments in Panama, BEPQ's H. H. Stage and C. F. W. Muesebeck fretted, "Biological deserts may be produced by heavy treatments of DDT and these would be, of course, highly undesirable. In fact, any upset in the balance of nature is very apt to produce conditions unfavorable to the general welfare of the plants and animals present. If, for example, insects are eliminated from a large area, young birds may subsequently starve as the result." The bureau's F. C. Bishopp voiced a similar sentiment. "In connection with DDT over large areas, serious consideration must now be given beneficial insects, as well as other animal and plant life because areas devoid of life might be created by too generous and indiscriminate applications of DDT."

These concerns were not merely hypothetical. In its haste to deploy DDT, the army and navy sometimes rushed it to theaters before trained personnel or appropriate equipment were available. Field officers made do with whatever was at hand. A naval medical officer reported the effect of this policy on Espiritu Santo, an island in the New Hebrides: "The first DDT in the Pacific arrived on this island in April 1944. When the Naval Medical Research Unit # 2 arrived there in May it was found that large overdoses had been made and *complete destruction of plant and animal life had occurred* [emphasis added]."

The report from Espiritu Santo contrasted with most by military medical officers, which usually focused on DDT's effects on target species. (USDA entomologists, on the other hand, often mentioned DDT's effects on other species, especially insect predators and parasites.) The committee that coordinated the army's insect control activities succinctly stated its view: "From a military standpoint, it was pointed out that insects fall into two categories: (1) Primary importance; mosquitoes, mites, flies (houseflies and biting flies), lice, fleas and ticks, and (2) Secondary importance; roaches, bedbugs and ants." Beneficial insects and "the balance of nature" did not rise above the horizon. Rather, the army aimed to develop "a single easy method of DDT application to suit all circumstances." Two civilian collaborators summarized the approach: "The ideal treatment would be one which kills not only all adults [mosquitoes] in the treated area *at the time of treatment*, but also whose which migrate into that area *subsequently*. This means rendering the area more or less permanently toxic [emphasis in original]."

These sentiments, and a sudden enthusiasm for eradicating species of insects from the earth, shocked Ross Harrison, an eminent biologist. He "stated that as a naturalist he was appalled by the great number of doctors, soldiers, and scientists seeking means to eradicate insects. As an old zoologist he pleaded for caution and advised discrimination in the extermination of insects with DDT."

Colonel J. W. Scharff, a British malarialogist who praised the role of DDT in protecting troops from malaria, shared Harrison's shock: "As an entomologist and lover of nature, I believe that the use of aerial spraying with DDT should be reserved for serious military emergencies. DDT is such a crude and powerful weapon that I cannot help regarding the routine use of this material from the air with anything but horror and aversion."

Entomologists and malarialogists were not the only scientists concerned about DDT's unintended effects. In May 1945, Clarence Cottam of the Fish and Wildlife Service asked that DDT not be released for civilian use until the service could assess its effects on wildlife. That summer, the service conducted tests at Patuxent River Refuge in Maryland. It found "that at 5 lbs. of DDT per acre, 50 mg. DDT per sq. foot, the population of singing birds was drastically reduced soon after spraying, and that both top-feeding and bottom feeding fish are killed at as low an amount of DDT as 1/2 lb. per acre. . . .

Stage, Muesebeck, Bishopp, Harrison, Scharff, and Cottam voiced these concerns in classified meetings and reports. In public, the Department of Agriculture stressed the need to learn how to use this powerful chemical safely. In April 1945, it released a report saying: "Even if supplies were available, say entomologists, DDT insecticides could not be generally recommended at this time. Too little is yet known about the harm that DDT may do to beneficial insects, plants, soil, livestock, wildlife, or to consumers of fruit and vegetables containing DDT residues."

By this time, however, the image of DDT as a wonder weapon was firmly fixed. The Department of Agriculture complained that "Many farmers have been led to believe that DDT is a panacea for most of their insect problems." For those who saw insects as barriers to health, wealth, or comfort, non-target species were usually of secondary concern or irrelevant. DDT's reputation was so great that Paul Müller, the Swiss chemist who discovered DDT's insecticidal properties in 1939, received the Nobel Prize for Physiology or Medicine in 1948.

A select group of researchers had another concern about DDT during World War II that has apparently remained unknown until now. On 17 August 1944, Ludwik Gross, an army doctor at Camp Forrest in Tullahoma, Tennessee, sent a letter to the army surgeon general. Gross pointed out that DDT may "perhaps be capable of producing tumors in susceptible individuals. No reference to such a possibility, negative or otherwise, has thus far been made in reports on DDT hitherto issued. The possibility of carcinogenic action of DDT should, however, be considered before large scale application of this powerful new insecticide has been undertaken." . . .

By this time, the army was fully committed to DDT. Demand had recently soared when researchers in Orlando developed equipment to disperse DDT from airplanes. Now the army could send fast combat airplanes over the jungle before American troops landed, significantly reducing malaria hazards during invasions, and spray even larger areas afterward. The dream of preventing disease by rendering areas "permanently toxic" seemed within reach. This goal spurred yet another expansion of DDT production. In May 1944, the army estimated that it would need over 4 million pounds of DDT for aerial dispersal in 1945, in addition to some 17 million pounds to be dispersed by other methods.

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Meanwhile, farm use of pesticides increased by more than fifty percent during that decade of environmental regulation. Agricultural uses of herbicides increased from 207 million pounds in 1971 to 451 million pounds in 1982. Over that same period, however, the use of insecticides declined from 126 million pounds to 71 million pounds. Among the obvious contributions to this declining use of insecticides were the increasing incidence of insect resistance and technology failures, the large influx of federal funding for IPM research following 1970, and the consequent growth in practical applications of IPM by corporate agriculture since the mid-1970s. . . . Thus the biological, economic, technological, legal, and political forces that encouraged pesticide use have all been undergoing a gradual, if incomplete and uneven, metamorphosis. It remains to be seen how far and how rapidly the diminution in insecticide use will proceed, how successful IPM approaches have become, and whether herbicide use will continue to escalate.

Aerial Spraying in Mexico

ANGUS WRIGHT

The changes in Mexico associated with rising chemical dependence in agriculture are changes that must be understood by those north of the border. The exodus from the Mexican countryside and the explosive growth of the entire population, combined with a formerly dynamic but currently stagnating economy, are all intimately connected with the project of agricultural modernization. These things also mean two vital things to those who live in the United States. There will be a rapidly growing flow of Mexicans into the United States, and there will be insistent demands for radical political changes in Mexico of a kind that the government of the United States is likely to see as extremely threatening to the security of the United States. . . . [T]he combination of political change in Mexico and a migration of more Mexicans into the United States will present transcendently important and complicated challenges to the government and people of the United States. Surprisingly enough, the story of how pesticides came to be so badly abused in Mexico is a good place to begin in coming to an understanding of the nature of these challenges. . . .

The multimillion-dollar annual harvest of the Culiacán Valley includes so many vegetables for export to the United States that Culiacán alone accounts for about a third to a half of the tomatoes, cucumbers, bell peppers, summer squash, zucchini, eggplants, and chili peppers sold in the United States between December and May. Valley farmers also grow safflower for oil, sugarcane, alfalfa, wheat, soybeans, and corn. The Culiacán Valley and its continued productivity are always a central concern of investment bankers and government economists a thousand miles south in Mexico City. . . .

Culiacán has been strongly connected to the economy of the United States for a long time. Relatively small-scale irrigation projects built in the nineteenth century provided water for sugar, cotton, and fresh vegetable production. Seventy-five percent of the irrigated land was owned by U.S. firms before the Mexican Revolution of 1910.

From Angus Wright, *The Death of Ramón Gonzáles: The Modern Agriculture Dilemma* (Austin: University of Texas Press, 1990), pp. xvii, 11–12, 15–21.

The land laws of the 1917 Constitutions made such ownership illegal, but U.S. companies are still strongly present in Sinaloa. Some land is owned by *prestanombres*, name loaners, who provide a front for foreign owners. Most of the financing for the vegetable farms comes from U.S. firms—according to the head of the National Union of Vegetable Growers, about 90 percent. . . .

Battles for control of the land have been prolonged and bitter. The corruption of the Mexican land reform system makes it possible for large landholders to operate under the cover of legal forms intended for cooperative owners or small private landowners. Small landholders and peasant groups and communities have fought back, and landholders have retaliated through their own private security forces, *la guardia blanca*, with the help of the state and municipal police force at times. Through the 1960s and 1970s these conflicts were often violent, with land invasions by peasants, kidnappings, and murders. But the real control the large landholders have is their integration with the private and public credit institutions, their control over the market, and their ability to corrupt or intimidate agrarian reform officials. Through the exercise of these various forms of control, they have largely excluded true small holders and cooperative farms from the valley in violation of the spirit and often the letter of the agrarian reform legislation. The most frequent legal facade for these operations is to rent land from the legal small holders or cooperatives, but the fact and conditions of rental are completely determined by the large landholder, who uses corruption and the threat of force to obtain rental agreements from people who know from experience that if they do not cooperate, they cannot succeed as farmers in the face of the opposition of the large operators. The small holders and cooperative members "end up as wage labor peons working on their land." . . .

[In 1987, about 250,000 migrant workers came to the Culiacán Valley to plant, cultivate, and harvest the vegetables to be exported north. The workers lived in squalid camps, or *campamentos*.] . . . [I]n many important ways the conditions of the camps [on the large farms] were . . . hazardous to the farm workers. This was especially true because of a major change that had been made in the kind of pesticides most frequently used by the growers. Pesticides that presented one set of hazards had been replaced by other pesticides that brought equal or greater danger of a different kind. The implications of this transformation cannot be understood without a brief description of the characteristics of some of the most widely used pesticides.

One way of classifying chemical pesticides is according to the time it takes them to break down into other compounds once they are released into the environment. There are the *persistent* pesticides that have half-lives—the amount of time it takes for half the material to break down into something else—measured in months, years, or decades. Among these persistents are most of the chlorinated hydrocarbons such as DDT, BHC, Toxaphene, aldrin, dieldrin, endrin, chlordane, lindane, and many others. It was the persistents that were most widely used in Culiacán until the late 1970s and the early 1980s.

There is a second class of pesticides that are *nonpersistent*, with half-lives of hours, days, or weeks. . . . The nonpersistent pesticides began to replace the persistents in Culiacán beginning in the late 1970s. By 1983, the nonpersistents had become dominant.

The nonpersistent chemicals are, in general and with important exceptions, much more acutely toxic than the persistents. . . .

Although the persistent DDT has only 2 to 5 percent of the acute toxicity of the nonpersistent parathion, DDT is the chemical that has been much more widely banned or restricted. . . . A nonpersistent such as parathion, on the other hand, will be a much more severe problem at the time and in the place of its release, but its rapid decay presumably assures that its overall effect on the environment will be less lasting, less complex, and more easily managed. It is for this reason that environmentalists in particular have worked hardest to limit the use of the persistent pesticides, even though the nonpersistents are typically much more acutely toxic to humans and most animals. . . .

Between my first visit to the fields of Culiacán in 1980 and my later visits in 1983 and later, a major shift occurred in pesticide use patterns, from heavy use of the persistents to the substitution of the nonpersistents. . . . [P]ests were becoming strongly resistant to the persistents because the persistents had been used more commonly than the nonpersistents. The persistents are typically cheaper than the nonpersistents, which accounts for the fact that they were the group used most in the early decades of synthetic pesticide use. . . . With time, though, growers were forced to shift to the generally more expensive nonpersistent pesticides as resistance grew in target pest populations.

The second reason for shifting to the nonpersistents has to do with the political and public relations problems of Culiacán growers in relation to their markets in the United States. As the persistents, such as DDT and the "drins" (aldrin, dieldrin, endrin), were more and more heavily restricted in the United States and other highly developed countries due to concerns over their environmental effects and their possible role in long latency diseases such as cancer, journalists and other researchers noted that these chemicals were still being commonly used in Mexico and other Third World countries. Chemical companies were marketing the persistents even more aggressively in the Third World in order to recover investments lost in richer countries. . . .

. . . In a muckraking book called *The Circle of Poison* (1981), journalists Weir and Shapiro called public attention to the fact that consumers in the United States were eating pesticides that had been manufactured in the United States and Europe, exported to places like Mexico because the chemicals were no longer allowed in the country of manufacture, and imported back into the United States and Europe as residues on food. This image of a circle of poison captured the imagination of many consumers and the attention of national and state legislators. Residue inspection programs at the border were somewhat improved, some consumers turned away from imports, and the Culiacán growers became seriously concerned about the loss of markets in the United States.

Mexican growers talked to Mexican public officials, who in turn talked to their counterparts in the United States. Agencies in the two countries signed technical agreements for the exchange of information, and technical advisers from the U.S. agencies offered their services to Mexico under the terms of the agreements. Upon consultation, the judgment that many growers had made on their own took hold—if the growers would switch even more rapidly than they already were switching (as a response to resistance in pests) to the nonpersistent pesticides, they would run fewer risks of losing out to competing growers in other countries and in Florida. With the combined incentive of responding to pest resistance and concerns of consumers in the United States, the Culiacán growers made a decisive turn to the use of the nonpersistent, very acutely toxic pesticides.

The logic of this shift was straightforward. Since the nonpersistents break down more rapidly, it would be easier to deliver vegetables to distant markets with low residue levels. Pesticides applied on crops would be largely decomposed by the time they reached the consumer. And since the nonpersistents were still largely permitted in the United States, any residue problems that did exist would not be different in kind from the residues encountered on domestic produce.

The trend toward the very acutely toxic nonpersistents in Culiacán had immediate and tragic consequences for farm workers. Most of the nonpersistent pesticides, as mentioned, are very acutely toxic. International, industry-supported standards require that anyone using such chemicals as parathion, methamidophos, guthion, phosdrin, or aldicarb should be thoroughly protected against contact with the poison through inhalation, ingestion, or skin absorption. In most cases, this means that people working with the chemical or working in fields recently sprayed with the substance should wear rubber shoes, a rubber apron or rubber coveralls, a hat, preferably of rubber or vinyl, and a mask or respirator.

In casual observation of hundreds of pesticide spray applications and systematic observation of fifty-two operations in the agricultural season of 1983–84, I never observed workers using any of this protective gear. In observation of ten spray operations in 1987, I observed one instance in which mixers using very acutely toxic materials were equipped with masks that they put on for a few minutes from time to time, and the pilot whose plane was spraying the mixture wore a respirator. In the other nine instances, foremen had made no provision for protective measures or gear. Even in the 1987 case of the mixers and pilot who had some protection, the pilot sprayed his highly toxic brew in a field only a few hundred yards from a *campamento* housing hundreds of people, and an old man and a young girl carrying a baby walked along the border of the field as it was being sprayed, with the material visibly drifting over them.

Although lack of proper gear is routine, it is certainly not the only abuse of safe pesticide use practices one observes in the fields of Culiacán. Growers have a choice of three different methods for pesticide application. They may order spraying by light aircraft, by tractor-drawn rigs, or by backpack spray rigs carried by individual workers, usually working in crews.

Aerial applicators operate in almost complete disregard for internationally recognized safety practices. In three instances, I observed aircraft spraying directly over crews of twenty to thirty workers—the sprays consisted of organophosphate insecticides mixed with copper and manganese-based fungicides. A television crew from CBS in Los Angeles filmed such an incident during the time I was doing fieldwork in Culiacán. A social worker employed by the growers' association told me, "We try to tell them how to protect themselves; to wear the proper gear, and to exhale when the plane passes over them in the field."

A common sight in Culiacán is a man standing at the edge of a field with an upraised flag, signalling to an approaching spray plane. The *bandalillero*, or flagman, is assigned the task of marking the boundary of the last pass taken by the pilot in spraying the field. Without such a moving marker, the pilot cannot determine where to fly without gaps and overlaps in the spray pattern. The flagman is sprayed dozens, even hundreds of times a day. Most flagmen run at the last minute to stay out of the thickest of the pesticide fog, but they nonetheless suffer heavy exposure. By universally recognized standards of safe practice, the *bandalillero* should be wearing a mask or respirator approved for use with the type of pesticides being used, and he should be well covered from head to foot in protective, impermeable gear. In observation of twenty-three *bandalilleros* at work in the Culiacán Valley, I never observed the use of any protective clothing other than a light cotton bandana worn across the face. . . .

Since the *campamentos* are in almost all cases surrounded on two, three, or four sides by fields running right up to the living areas, the lack of drift control means that everyone living in the camps is exposed to a variety of acutely toxic substances on a more or less regular basis, even in the case of children too young to work in the fields.

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CHAPTER
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The Military-Industrial-University Complex, 1945–1990

In American (and world) history, war and the preparations for it have had an extraordinary influence on technological change, industrialization, and economic development. In terms of scale and impact, however, World War II marked a dramatic departure in the application of science and engineering to military operations. The most famous example is the Manhattan Project, which resulted in atomic weapons and the devastation of Hiroshima and Nagasaki in 1945. But the massive wartime deployment of engineers and scientists also spawned a large array of new technologies, including radar, the proximity fuse, antibiotics, new chemical insecticides, analog and electronic digital computers, and the mass production of everything from tanks to paratrooper boots.

The institutional arrangements that fostered these technologies were equally unprecedented. Partly through the efforts of Vannevar Bush, an academician, engineer, and entrepreneur, a productive (and, as it turned out, lasting) alliance was forged during the war years among academic scientists, engineers, and the military. Research universities became integral components of what President Dwight Eisenhower would later describe as the "military-industrial complex." University involvement in the war effort influenced not only military-industrial matters but the shape of higher education in the postwar period.

In contrast to the Civil War, the Spanish-American War, and World War I, the United States did not completely demobilize with the defeat of the Axis powers in 1945. The close relationship that the federal government had forged with industry and academia during the war extended into the Cold War, an arrangement just as evident in the laboratories of Stanford and MIT as in the factories of General Electric and Boeing. Who were the architects of the new arrangement between industry, academia, and the military and what were their objectives? What effect did the new arrangement have on the kind of science and engineering that was supported in postwar America, and what were its implications for the larger political economy?