The Strange Career of DDT

Experts, Federal Capacity, and Environmentalism in World War II

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It was a glorious day for environmentalists when the federal government sharply restricted the use of the insecticide dichlorodiphenyltrichloroethane, or DDT. Federal regulators prohibited "general outdoor application" of DDT in the United States because of apprehensions about the insecticide's effect on wildlife and "the balance of nature." The policy stated that, while it may be "necessary to ignore these considerations" in other parts of the world, "in the United States such considerations cannot be neglected." Although concern for wildlife protection motivated federal regulators, they also knew about DDT's potential impact on human health, including its potential to cause cancer and its ability to pass from mother to baby in milk. The sweeping policy required anyone—citizens, companies, government agencies—to get permission from a committee of experts before they could spray DDT from the air inside the United States. The committee, which would include representatives from the Fish and Wildlife Service, the Public Health Service, and other federal agencies, would grant permission only in rare circumstances.

Contrast that view with DDT's reputation in January 1945, when the chief of preventive medicine for the United States Army announced that DDT would be "the War's greatest contribution to the future health of the

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world." Upon DDT's release to civilians in August 1945, public health officials, farmers, and homeowners snapped up the wonder chemical to kill insects that caused disease, attacked crops, or created a nuisance. In 1948, DDT developer Paul Müller received the Nobel Prize in physiology or medicine.[1]

Many scholars have pointed out that DDT's trajectory from hero in 1945 to pariah in 1972 illustrates sea changes in American values, science, and politics.[2] In an influential study of environmentalism, Samuel P. Hays argued that government experts did not know about or look for ways that DDT might harm people or wildlife until well after its introduction. "Early governmental concern with pesticides," Hays wrote, "had been confined to their efficiency, that is, whether they killed pests as effectively as manufacturers claimed. Not until the 1960s did concern extend to their effects on people and on the environment." These new, broader criteria led scientists to discover unforeseen, long-term problems with insecticides.[3] Regulation of DDT and other toxic substances then came about because outsiders pressured governmental insiders. As Hays contended, "the public sought to work out control strategies, to determine and set acceptable exposure limits, and to devise methods of containment when the social institutions could not." Experts and activists forced the U.S. Environmental Protection Agency to ban most uses of DDT in the United States in 1972.[4]

1. James S. Simmons, "How Magic is DDT?" *Saturday Evening Post*, 6 January 1945, esp. 86; "War on Insects," *Time*, 27 August 1945, 65; Bernard S. Schlessinger and June H. Schlessinger, eds., *The Who's Who of Nobel Prize Winners 1901–1905*, 3rd ed. (Phoenix, Ariz., 1996), 110–11.

2. Thomas R. Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton, N.J., 1981); Margaret Humphreys, "Kicking a Dying Dog: DDT and the Demise of Malaria in the American South, 1942–1950," *Isis* 87 (March 1996): 1–17; Paolo Palladino, *Entomology, Ecology, and Agriculture: The Making of Scientific Careers in North America, 1885–1985* (Amsterdam, 1996); John H. Perkins, "Reshaping Technology in Wartime: The Effect of Military Goals on Entomological Research and Insect-Control Practices," *Technology and Culture* 19 (1978): 169–86, and *Insects, Experts, and the Insecticide Crisis: The Quest for New Pest Management Strategies* (New York, 1982); Edmund P. Russell III, "'Speaking of Annihilation': Mobilizing for War against Human and Insect Enemies, 1914–1945," *Journal of American History* 82 (March 1996): 1505–29; Richard C. Sawyer, *To Make A Spotless Orange: Biological Control in California* (Ames, Iowa, 1996); and Merritt Roe Smith and Gregory Clancey, eds., *Major Problems in the History of American Technology* (Boston, 1998), 384–426.

3. Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955–1985* (New York, 1987), 3, 174; Angus A. MacIntyre stressed the unforeseen nature of DDT problems when he wrote that during World War II DDT's developers focused on "acute, short-term toxicity to persons directly exposed. . . . We simply did not understand the chronic adverse impacts of DDT"; "Why Pesticides Received Extensive Use in America: A Political Economy of Agricultural Pest Management to 1970," *Natural Resources Journal* 27 (1987): 533–78.

4. Hays, 3, 173–77; Dunlap, 234–45.

OCTOBER
1999
VOL. 40

A body of work from other scholars suggests a new, related hypothesis: because DDT entered the United States as a military technology, and because the armed forces have been among the biggest polluters in the country, we should not be surprised if they ignored potential environmental damage when developing DDT. The plausibility of that hypothesis grows when we note that military-industrial complexes, including those involving the army and pesticide makers, created some of the most polluted sites in the United States. At Colorado's Rocky Mountain Arsenal, manufacturing of chemical weapons (by the army) and pesticides (by Shell, which rented space at the arsenal) combined to create a vast toxic waste dump.[5]

Persuasive as they appear to be, these views of DDT's history have problems. The policy outlined in the first paragraph of this article came not from the well-known 1972 ban on DDT but from an overlooked 1945 policy. The army, along with the Public Health Service, issued the policy, not the Environmental Protection Agency.[6]

According to the received interpretation sketched above, the federal government should not have issued the 1945 policy. At that time, no one should have worried about the impact of pesticides on wildlife and human health. Even if wildlife and public health agencies had worried about such issues, they should not have been powerful enough to override agencies committed to "producer" values. Even if agencies agreed on the desirability of restricting technology for environmental reasons, the lack of enabling legislation should have stymied regulation. Even if legislation had permit-

5. Terrence R. Fehner and F. G. Gosling, "Coming in From the Cold: Regulating U.S. Department of Energy Nuclear Facilities, 1942–1996," *Environmental History* 1 (April 1996): 5–33; Barton C. Hacker, *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing, 1947–1974* (Berkeley, 1994); Seth Shulman, *The Threat at Home: Confronting the Toxic Legacy of the U.S. Military* (Boston, 1992); Mark Obmascik, "Arsenal Billions Away from Being Picnic Site," *Denver Post*, 14 February 1987; "Pine Bluff Arsenal," *Armed Forces Chemical Journal* 4 (April 1951): 22–25.

6. "Use of DDT for Mosquito Control in the United States, A Joint Statement of Policy by the U.S. Army and the U.S. Public Health Service," attached to C. L. Williams to the Surgeon General, U.S. Army, 20 April 1945, 725.11 Prevention and Restriction 1945, General Subject File, Record Group 112: Office of the Surgeon General, United States Army, Washington National Records Center, Suitland, Maryland (hereafter cited as RG 112); Robert C. Dunn to Paul A. Neal, 23 August 1944, M. I. Smith and R. D. Lillie to P. A. Neal, 22 August 1944, and H. E. Fraser to Norman T. Kirk, 24 August 1944, 441 (DDT) July–December 1944, General Subject File 1943–44, RG 112; Geoffrey Woodard, Ruth R. Ofner, and Charles M. Montgomery, "Accumulation of DDT in the Body Fat and Its Appearance in the Milk of Dogs," *Science*, 27 July 1945, 177–78; A. L. Ahnfeldt to the Surgeon General, U.S. Public Health Service, 7 July 1945, Ahnfeldt to P. H. Annand, 7 July 1945, Ahnfeldt to Ira N. Gabrielson, 7 July 1945, O. R. McCoy and Thomas A. Hart to Frederick C. Lincoln, 8 August 1945, 334 (Committees) January–June 1946 [discrepant dates in original], General Subject File, RG 112.

ted regulation, the army should have escaped it and done what it wanted regardless of impact on wildlife.

So how do we make sense of the policy? Perhaps it was an anomaly. Bureaucrats have, after all, sometimes taken actions that they later saw as hasty or ill advised. Or perhaps we need a new framework for understanding DDT and environmentalism. Distinguishing between the two hypotheses summarized above requires a look at the little-studied history of DDT during World War II, and that will be the focus of this article. The evidence presented here, drawn largely from formerly classified archival records, contradicts the first hypothesis and supports the second. The 1945 policy grew out of scientists' concerns about environmental impacts of DDT. These concerns came not from the public or other "outsiders," but from government scientists themselves. Before the chemical's 1945 release to the public, scientists and industry officials examined the chemical's effect on people, plants, and animals, relied on test results to decide how and where to use DDT, and restricted uses while conducting tests.

Coupling this evidence with the more extensive literature on the postwar period enables us to see that, contrary to the argument of Hays and others, expert values and evaluation criteria did not differ radically between 1945 and 1972. Nor was outside pressure necessary for government regulation. At both times federal experts worried about the impact of pesticides on wildlife and human health, and at both times the federal government restricted DDT's use for those reasons.[7]

Why, then, did the federal government permit the widespread use of DDT between 1945 and 1972? To answer that question, we need to take a fresh look at the relationship between experts, the federal government, and environmental regulation. The literature on environmentalism and DDT has often described federal environmental policy as the result of social changes or struggles among interest groups from outside government. Hays, for example, has written that as new "personal and public values . . . work themselves from society into politics, social changes become political changes." Thomas R. Dunlap has argued that restrictions on DDT resulted from "actions of groups and individuals outside the normal network of regulation who worked out new methods of influencing policy."[8]

The evidence for those arguments is abundant, but we also have evidence that the federal government has done more than follow social trends and referee fights among interest groups. It has also led. Stephen Skowronek has argued that the federal government grew in the late nineteenth

7. Scientists in 1945 did not predict all the harmful effects of DDT that were known by 1972, such as its potential to reduce bird populations by weakening eggshells. But the discovery of new effects did not create apprehension; it added to existing concerns. See Dunlap.

8. Hays, 2; Dunlap, 241; Christopher J. Bosso, *Pesticides and Politics: The Life Cycle of a Public Issue* (Pittsburgh, 1987).

OCTOBER
1999
VOL. 40

and early twentieth centuries "not simply [as] a gradual accretion of appropriate governmental responses" to problems that citizens brought to its attention, but rather as "an exercise in reconstructing an already established organization of state power" and creating an administrative state. Brian Balogh has charted the rise of the "prominstrative state," which fused experts with federal administrative capacity, in World War II and the cold war. The prominstrative state did not simply respond to problems; it developed experts, and its experts helped set the national agenda.[9]

But the capacity of the federal government to organize and act upon expertise varied across programs and time. Therein lies a solution to the puzzle of DDT's strange career. In 1945 and 1972, the federal government had relatively high capacity vis-à-vis DDT. Its capacity to control environmental technology was lower in the intervening years, when a more decentralized economic and political system facilitated widespread use of DDT.

The relatively high federal capacities of 1945 and 1972 resulted from different forces. In 1945 the cause was war. As this article will show, the army and the Public Health Service controlled the use of DDT because of the chemical's importance for quelling insect-borne diseases that threatened troops. It relied on civilian scientists to develop and recommend uses for DDT. These scientists used broad criteria to evaluate the chemical, and the army responded to their advice. The relatively closed world of military decision making permitted a roomful of officers and civilian scientists to control technology using the criteria they found persuasive, resulting in what we could call environmental regulation.

This roomful of people had little power to control DDT in its next regulatory phase, which stretched from the end of World War II until 1972. The pattern that would dominate that period was clear by August 1945, the endpoint of this article's narrative. Control of DDT passed from military to civilian hands, which for all practical purposes meant from government to private industry and consumers. No post–World War II federal agency had the authority, much less the desire, to keep DDT off the civilian market (though several agencies wanted to see more research before public sales).[10]

9. Brian Balogh, "Reorganizing the Organizational Synthesis: Federal-Professional Relations in Modern America," *Studies in American Political Development* 5 (spring 1991): 119–72, and *Chain Reaction: Expert Debate and Public Participation in American Commercial Nuclear Power, 1945–1975* (New York, 1991); Stephen Skowronek, *Building a New American State: The Expansion of National Administrative Capacities, 1877–1920* (New York, 1982), viii–ix, 287; Peter B. Evans, Dietrich Rueschemeyer, and Theda Skocpol, eds., *Bringing the State Back In* (New York, 1985); Robert Higgs, *Crisis and Leviathan: Critical Episodes in the Growth of American Government* (New York, 1987); and Ira Katznelson and Bruce Pietrykowski, "Rebuilding the American State: Evidence from the 1940s," *Studies in American Political Development* 5 (fall 1991): 301–39.

10. Federal regulations required manufacturers to label their products accurately and prohibited farmers from marketing products that carried pesticide residues exceeding specified levels; neither of these enforcement mechanisms kept products off the market.

In this pluralistic system the voices of a handful of scientific experts could hardly be heard above the clamor of public praise for DDT's wonders. Experts talked to each other in professional arenas, but their audience no longer controlled DDT's fate. The market offered few incentives for producers and consumers to consider long-term costs to wildlife or human health.

The third phase, a return to tight government control of DDT, came after scientists and activists had formed or expanded groups concerned about the environment. Backed by growing public support for environmental values, those groups exerted legal and political pressure on the federal government. Their efforts led to increased capacity (government expertise and intervention in markets) and made possible the 1972 ban on DDT.[11]

What this article suggests, then, is that the United States traveled two routes to environmental regulation, and that such regulation began earlier than we have thought. Both routes required high federal capacity, but capacity developed in different ways at different times. High military capacity developed quickly under the press of World War II; high civilian capacity developed slowly as interest groups pressed for more government regulation.

This article also highlights the differences between military, industrial, and scientific evaluations of technology. (Here "scientific" is shorthand for the small group of government entomologists and public health researchers who evaluated DDT during World War II. This article does *not* suggest that all scientists or government employees held the same views, values, or incentives as did actors in this story.) Americans have long assumed that war heroes would prove equally adept at solving civilian problems (witness the number of former generals elected president). In a similar way, Americans have assumed that technological war heroes would prove equally adept at solving civilian problems. In the case of DDT, wartime publicity created a popular impression of DDT as a miracle chemical. Civilians concluded that DDT would prove equally suitable for solving insect problems on farms and in homes. But government researchers distinguished between DDT's suitability for military and civilian use. The same criteria—persistence and wide spectrum of action—that made DDT ideal for killing disease-bearing insects on battlefields also raised doubts about its suitability for farm fields. Persistence might lead to dangerous residues on food, and a wide spectrum of action might lead to harm for nontarget species.

On the other hand, industrial (or market) criteria for evaluating DDT more closely resembled military than (what government scientists during World War II called) civilian criteria. Wide spectrum of action and persistence made DDT appealing to industry for civilian sales, for they made DDT

Dunlap (n. 2 above), 39–55, 63; James Whorton, *Before Silent Spring: Pesticides and Public Health in Pre-DDT America* (Princeton, N.J., 1974).

11. Dunlap, 59–245.

OCTOBER
1999
VOL. 40

effective against a variety of pests for long periods. In the market system, lawsuits provided the main mechanism for incorporating external costs into product price. Some companies chose to stay out of the civilian market at first for fear of such suits. But when DDT failed to cause large-scale, recognizable harm and suits did not arise, a host of companies rushed to market without having to incorporate such costs. The market never did factor potential harm to people and other nontarget species into the price of DDT, and it took government regulation to address what many people saw as significant costs to people and wildlife.

* * *

Before looking at DDT itself, let us examine the problems its developers faced. When the United States mobilized for World War II, planners took to heart a dismal lesson from World War I: insect-borne diseases could nullify a nation's military might. Typhus had killed two and a half million people along the eastern front. If anything, the likelihood of fighting in tropical areas made the risks of insect-borne diseases even worse in World War II. By one estimate, half the American troops in malaria-infested areas could become casualties in the first mosquito season.[12]

Responsibility for preventing disease among troops fell to medical officers of the armed services. One of their most valuable allies was the Office of Scientific Research and Development (OSRD). Organized for World War II, the office mobilized civilian scientists and organizations for the armed forces by letting research contracts. One of these organizations was the Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture, which the OSRD asked to research ways to prevent insect-borne diseases.[13]

The Bureau of Entomology and Plant Quarantine devoted its Orlando, Florida, laboratory to the war effort. The Orlando entomologists believed that war conditions required a different set of criteria for evaluating technology than did peacetime. Instead of focusing on a few species in relatively fixed areas, they would look for methods that could be transported worldwide to control a variety of species. And they would look for quick, rather than ideal, solutions to problems.[14]

12. James Phinney Baxter III, *Scientists Against Time* (Boston, 1946), 301–4; Stanhope Bayne-Jones, "Typhus Fevers," in *Communicable Diseases: Arthropodborne Diseases Other Than Malaria*, vol. 7 of *Preventive Medicine in World War II*, U.S. Army Medical Service (Washington, D.C., 1964), 175–274, esp. 181–82.

13. Perkins, "Reshaping Technology" (n. 2 above).

14. Bureau of Entomology and Plant Quarantine, "Investigations on the Control of Insects and Other Arthropods of Importance to the Armed Forces Conducted by the Orlando, Fla., Research Laboratory, April, 1942 to October, 1945," National Research Council Insect Control Committee Report No. 158, Final Report, 1–8, OSRD Insect Control Committee Reports—Numbered—Volume III, Committees on Military

At the urging of the army, the Orlando laboratory made typhus control its first priority. Until 1942, the army killed lice, and thus controlled typhus, by steaming clothes and bedding. That method was adequate in peacetime but ill suited to war, especially near front lines. Steam chambers were slow and clumsy, produced smoke that was easily spotted by enemy soldiers, failed to kill lice clinging to the body, and did not prevent reinfestation.[15]

The Army suggested a new tack that might be more suitable to mobile warfare: a louse-killing powder that soldiers could carry and apply themselves. The Orlando researchers decided that such a powder should meet four criteria for efficacy. The ideal powder would kill lice quickly, work at low concentrations, be persistent (kill lice for weeks), and be thorough (kill all lice exposed to the chemical).[16]

Finding a chemical to meet all four criteria was hard. Orlando entomologists screened some eight thousand chemicals for efficacy by placing them in beakers with lice. About four hundred passed. These went on to a combined test of efficacy and human safety called the "arm-and-leg test," in which researchers dusted compounds on cotton cloth, added lice, and taped the cloth to arms and legs of human subjects. Researchers added more lice daily to test for persistence. Only a few compounds remained effective for long periods and did not irritate the skin, and only these few proceeded to the "dormitory" (or "barracks") test. Researchers infested men with lice, dusted them with chemicals, and confined the men to a dormitory until the chemical in their clothing failed to kill lice. Confinement often lasted a month and could stretch as long as 70 days.[17]

The most promising chemical was pyrethrum, which came from dried flower heads of several species of chrysanthemum. The Bureau of Entomology and Plant Quarantine recommended a pyrethrum powder to the Committee on Medical Research in August 1942, and the armed forces adopted it as their standard louse killer.[18]

Medicine, Minutes (Bulletins) and Reports, Division of Medical Sciences 1940–1945, National Research Council, National Academy of Sciences Archives, Washington, D.C. (hereafter cited as NRC).

15. George C. Dunham, *Military Preventive Medicine* (Carlisle Barracks, Pa., 1930), chap. 22; E. C. Cushing, *History of Entomology in World War II* (Washington, D.C., 1957), 23.

16. Bureau of Entomology and Plant Quarantine, "Investigations on the Control of Insects."

17. Ibid., 26; L. C. McAlister Jr., G. H. Culpepper, and N. B. Carson, "Treatment of Research Subjects with Introduced Infestation of Body Lice in a Camp Dormitory, Orlando, Florida, Monthly Report, September 1942," Insect Repellents no. 2, September–December 1942, Correspondence, Committees on Military Medicine, Division of Medical Sciences, NRC.

18. Edward F. Knipling, "Insect Control Investigations of the Orlando, Fla., Laboratory During World War II," in *Annual Report of the Board of Regents of the Smithsonian Institution, 1948* (Washington, D.C., 1948), 331–48, esp. 335.

OCTOBER
1999
VOL. 40

The Orlando tests provided rough evidence of the powder's safety for people, but the OSRD enlisted pharmacologists for further tests on animals. H. O. Calvery, chief of the Food and Drug Administration's Division of Pharmacology, oversaw these tests. Like the Orlando entomologists, Calvery believed that evaluating a technology for use by soldiers in wartime called for a different set of criteria than those used by civilians in peacetime. When judging the safety of pyrethrum powder, Calvery factored in the risk of typhus (he noted that, by August 1942, typhus had felled twenty thousand troops in Africa), the risk posed by the powder (preliminary tests showed found the powder had "a very low toxicity and [is] nonirritant"), and the urgency of finding a solution. He concluded that "the benefit which can be derived from their use will far outweigh any harmful effects resulting from their possible toxicity."[19]

Pyrethrum powder was a great help on the typhus front, but the armed forces were losing the battle with malaria. Again at the army's request, Orlando entomologists scrambled to find an effective way to fight malaria-carrying (*Anopheles*) mosquitoes. The standard method was to stop mosquitoes from reproducing by draining, oiling, or poisoning breeding areas. Beginning in October 1942, the Orlando laboratory sought a chemical to kill mosquito larvae in water. This method would be useful to the army in long-secure rear areas. But, as the Orlando entomologists put it, this method did not suit the "highly mobile type of warfare such as is used in the present war." Even if an army started "larviciding" areas as soon as they invaded, troops "may be exposed for several weeks to infected vectors already present. . . . By the time antilarval measures are able to reduce the mosquito populations troops may move into new infected areas." So the Orlando researchers focused most of their effort on finding "an effective and rapid means of destroying adult mosquitoes."[20]

One of the most promising new methods was aerosol spraying. In 1941, Department of Agriculture entomologists had discovered the principle of using a propellant gas to disperse insecticidal mixtures in a fine mist. In the

19. H. O. Calvery to W. G. Campbell, 11 August 1942, 1, Insect Repellents no. 1, September 1940–August 1942, Correspondence, Committees on Military Medicine, Division of Medical Sciences 1940–1945, NRC.

20. Paul A. Harper et al., "New Hebrides, Solomon Islands, Saint Matthias Group, and Ryukyu Islands," in *Communicable Diseases: Malaria*, vol. 6 of *Preventive Medicine in World War II*, U.S. Army Medical Service (Washington, D.C., 1963), 399–496, esp. 426–34; Mary Ellen Condon-Rall, "Allied Cooperation in Malaria Prevention and Control: The World War II Southwest Pacific Experience," *Journal of the History of Medicine and Allied Sciences* 46 (1991): 493–513; Knipling, 337; Bureau of Entomology and Plant Quarantine, "Insecticides and Insect Repellents Developed for the Armed Forces at the Orlando, Fla., Laboratory," revision of Tropical Diseases Report No. 19, Report No. 100, 1 July 1945, 22, OSRD Insect Control Committee Reports—Numbered —Volume II, Committees on Military Medicine, Minutes (Bulletins) and Reports, Division of Medical Sciences 1940–1945, NRC.

summer of 1942, manufacturers developed a small metal container with freon-12 as propellant and pyrethrum as insecticide. With a net weight of about one pound, each container treated 150,000 cubic feet of space. Small, round, and born in war, these containers were dubbed aerosol "bombs." (These bombs were the forerunners of today's aerosol cans.) They quickly became popular for killing mosquitoes in confined spaces. By March 1943 about six hundred thousand aerosol bombs had been manufactured.[21]

Unfortunately for the army, the two most effective advances in insecticide technology, louse powder and aerosol bombs, relied on dwindling supplies of pyrethrum. Before the war, the United States had imported pyrethrum from Japan, Dalmatia, and Kenya. The war had cut off supplies from all but Kenya, and that supply was threatened. By July 1943, the chief of preventive medicine for the U.S. Army, James S. Simmons, believed that the most important task civilian researchers could do for military medicine was "finding a substitute for pyrethrum."[22]

The stage was set for DDT's heroic entrance. Researchers had defined the problem (killing insects that carried typhus and malaria), the preferred way to solve the problem (an insecticide), their criteria for evaluating insecticides (weighing risks of disease on battlefronts against risks of exposure to the chemical), and the time frame in which they had to make a decision (immediately).

Orlando researchers screened every chemical they could find. In October 1942, the Swiss chemical company Geigy had given federal entomologists some reports showing that a new chemical killed insects and was "relatively non-toxic to man and animals." Geigy sent a sample of the chemical, later dubbed DDT, to federal entomologists on 3 November 1942.[23] Tests in Orlando made DDT look "magical": it was highly toxic to insects, worked at small doses, and killed insects for a long time. According to one story, ducks flying from treated to untreated ponds carried enough DDT on their bodies to kill the mosquito larvae in the untreated ponds. DDT powder killed lice for four times longer than did pyrethrum powders. Sprayed on walls of buildings, DDT killed adult mosquitoes for months. (Orlando researchers later developed equipment to disperse DDT from airplanes, which enabled the army and navy to control mosquitoes quickly

21. Oliver R. McCoy, "War Department Provisions for Malaria Control," in *Communicable Diseases: Malaria*, U.S. Army Medical Service, 11–60, esp. 40.

22. Minutes of the Fourth Conference on Insect Repellents, 14 July 1943, 1, Committees on Military Medicine, Division of Medical Sciences, NRC.

23. Victor Froelicher, "The Story of DDT," *Soap and Sanitary Chemicals*, July 1944, esp. 117; R. C. Roark to P. N. Annand, 6 January 1945, History of Development—Bureau of Entomology and Plant Quarantine—World War 2 1945, History of Defense and War Activities 1941–50, Correspondence and Reports, Record Group 7: Bureau of Entomology and Plant Quarantine, Washington National Records Center, Suitland, Maryland (hereafter cited as RG 7).

OCTOBER
1999
VOL. 40

and cheaply over large areas.) Plus, unlike pyrethrum, DDT could be manufactured in the United States.[24]

But was DDT safe? H. O. Calvery at the Food and Drug Administration and M. I. Smith at the National Institute of Health fed animals DDT to see its effects. As 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.[25]

That gamble proved to be a good one. Further evidence showed that skin absorbed little or no DDT from dusts. After the first three months of working with DDT, subjects and researchers in Orlando showed no evidence of sensitization or of toxic symptoms. Tests on animals at the Food and Drug Administration convinced researchers that DDT dusts were "entirely safe."[26] In May 1943, federal entomologists recommended, and the army adopted, DDT as a louse powder.[27]

Adoption did not mean that questions about DDT's safety had been resolved. None of the researchers—entomologists, physicians, or pharmacologists—had concluded that DDT was harmless. Rather, as H. O. Calvery put it in July 1943, "the hazards must be weighed against the great advantages of the materials."[28] By this point, Calvery and his colleagues had identified three potential hazards that, in light of later events, deserve our attention.

The first was the effect of DDT in solvents. Skin absorbed little DDT from dusts, but it readily absorbed DDT from solution. By May 1943, M. I. Smith at the National Institute of Health had discovered that dissolved DDT, when painted on bellies of rabbits, led to tremors and paralysis. DDT

24. Simmons, "How Magic is DDT?" (n. 1 above); Baxter (n. 12 above), 370; James S. Simmons to Guy Denit, 7 April 1944, 441 (DDT) July–December 1944, Security Classified General Subject File, RG 112; Roark to Annand, 6 January 1945; Froelicher, 117.

25. Simmons, "How Magic is DDT?" 85; Pyrethrum Mission, "Summary 1, Neocid," 11 May 1943, HD725 Insect Control Malaria—Repellents and Insecticides 1943–1945, Southwest Pacific Area, RG 112; James S. Simmons to D. T. Richardson, May 12, 1944, 441.-1, DDT, Southwest Pacific Area, RG 112.

26. Pyrethrum Mission, "Summary 1, Neocid," and "Supplementary Report, Summary 1, GNB (Neocid)," 8 June 1943, HD725 Insect Control Malaria—Repellents and Insecticides 1943–1945, Southwest Pacific Area, RG 112.

27. Knipling (n. 18 above), 336; "DDT Outlook," *Soap and Sanitary Chemicals*, June 1944, 127.

28. Minutes of the Fourth Conference on Insect Repellents, 14 July 1943 (n. 22 above).

solutions killed some rabbits. These findings led Calvery to warn that DDT solutions should not be allowed to contact skin.[29]

The second hazard was the impact of long-term exposure to DDT, both on the skin and in food. In August 1943, Calvery reported that rubbing rabbits with DDT ointments daily for twelve weeks led, even at low doses, to necrosis of muscles and organs, kidney damage, atrophy of testes, dermatitis, dehydration, emaciation, and death. In feeding experiments, almost all test animals showed "slight to moderate liver damage." Some showed "slight terminal gastric bleeding," "slight to moderate testicular atrophy," or "degenerative cellular changes" in the thyroid. But the effects varied among species, and Calvery concluded that more long-term studies would be needed before one could judge DDT's safety for people.[30]

The third hazard was the effect of DDT when inhaled. Tests by Paul A. Neal of the National Institute of Health's Division of Industrial Hygiene set this concern to rest. He and his team found that species varied in their response to DDT aerosols. Mice often died, while monkeys "showed no signs or symptoms of any toxic action." When Neal exposed dogs to "massive doses" of DDT dust, he found it "caused neither toxic effects nor definite pathological changes." Most importantly, given differences among species in reactions to DDT, Neal tested aerosols on two human beings "without showing evidence of subjective or objective signs of [DDT] poisoning." In September 1943, he reported that DDT was safe when used as an aerosol, dust, or mist.[31]

29. Pyrethrum Mission, "Summary 1, Neocid" and "Supplementary Report, Summary 1, GNB (Neocid)"; Minutes of the Fourth Conference on Insect Repellents, 14 July 1943.

30. Herbert O. Calvery, "Bimonthly Progress Report No. 4, Toxicity of Insect Repellents and Lousicides," 31 August 1943, U.S.A. Typhus Commission DDT-Reports (1943), U.S.A. Typhus Commission, RG 112; "Statement by Dr. H. O. Calvery Regarding the Toxicity of DDT—Committee on Medical Research of the Office of Scientific Research and Development—Tropical Diseases Report no. 19. (First Revision, 30 May 1944, of Tropical Diseases Report no. 17)," attached to Clara L. Day to Clark Yeager, 27 February 1945, 441.(DDT) January–June 1945, General Subject File 1945–46, RG 112; "DDT Toxicity Studies," *Soap and Sanitary Chemicals*, December 1944, esp. 149.

31. P. A. Neal et al., "Toxicity and Potential Dangers of Aerosols, Mists, and Dusting Powders Containing DDT," in *Supplement No. 177 to the Public Health Reports* (Washington, D.C., 1944), 2; W. F. von Oettingen and Paul A. Neal, "Fourth Preliminary Report on the Toxicity and Potential Dangers of Gesarol Insecticides with Special Reference to their Toxicity by Inhalation for August 1943," U.S.A. Typhus Commission Louse Powder—MYL, U.S.A. Typhus Commission, RG 112; P. A. Neal, "Summary of Conclusions of the Report on the Toxicity and Potential Dangers of Gesarol, as Reported at the Meeting of the National Research Council on September 28, 1943," Insect Repellents no. 3, Correspondence, Committees on Military Medicine, Division of Medical Sciences, NRC; P. A. Neal et al., "Final Report on the Toxicity and Potential Dangers of Gesarol" [May–September 1943, handwritten], 49–50, U.S.A. Typhus Commission DDT-Toxicity, U.S.A. Typhus Commission, RG 112.

Neal's findings opened the stopcock on DDT. James Simmons noted that Neal gave "final assurance that the material is not dangerous for use under the conditions which we had selected," and the army requested "a great expansion" in DDT production.[32] That expansion came just in time for DDT's name to go up in international lights. During the winter of 1943–44, 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 (another botanical insecticide favored by the British), which "broke the back" of the epidemic. Then DDT arrived and permitted wider dusting. This event marked the first time a typhus epidemic was halted in wintertime, and DDT received much of the credit.[33]

DDT's reviews could not have been better. 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." *Better Homes and Gardens* called DDT "A deadly new bug killer as potent against insects as the sulfas and penicillin are against disease." *Reader's Digest* promised "total victory on the insect front." In June

32. James S. Simmons to D. T. Richardson, 12 May 1944, 441.-1, DDT, Southwest Pacific Area, RG 112. Surviving documents do not explicitly state why the army relied on Neal's tests more than on Calvery's, but two reasons seem likely. First, medical doctors placed great weight on clinical experience. One of the army's key actors was Gen. Stanhope Bayne-Jones. He received a memo saying: "Whether minute quantities of DDT ingested in this manner [from food] will prove harmful has not been determined." He wrote on the memo, "I should say that this has been determined—Major Wheeler and others [illegible] dusting whole and get into the mouth a considerable amount of powder (10% DDT)." Clarence Guyton to Stanhope Bayne-Jones, 17 July 1944, U.S.A. Typhus Commission DDT—Toxicity, U.S.A. Typhus Commission, RG 112. Second, the conditions under which Neal tested animals more closely resembled the conditions under which the army would be using DDT. When Surgeon General Thomas Parran declared DDT safe, he specified exactly the forms that Neal had tested ("a 1% to 5% solution of gesarol in 10% cyclohexanone with 89 to 85 per cent Freon as an aerosol, or in concentrations up to 10% in inert powders for dusting clothes, or the use of a 1% Gesarol-Deobase Mist." Gesarol was an earlier name for DDT.). Thomas Parran to L. H. Weed, 27 October 1943, Insect Repellents no. 3, Correspondence, Committees on Military Medicine, Division of Medical Sciences, NRC. Neal later became even more convinced that his clinical studies showed DDT's safety. To collect data on the effects of DDT on humans, his team studied 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." P. A. Neal et al., "Results of Examinations of Three Men Having Relatively Long Continued Occupational Exposure to DDT," 1 August 1944, U.S.A. Typhus Commission DDT—Toxicity, U.S.A. Typhus Commission, RG 112.

33. Dunlap has pointed out that factors other than DDT, such as the case-finding method and botanical insecticides, were also important but received less publicity. Dunlap (n. 2 above), 62; "DDT Considered Safe for Insecticidal Use," *American Journal of Public Health* 34 (1944): 1312–13, esp. 1313.

1944, *Time* announced that DDT was "one of the great scientific discoveries of World War II. . . . It promises to wipe out the mosquito and malaria, to liquidate the household fly, cockroach and bedbug, to control some of the most damaging insects that prey on the world's crops." The *Chicago Tribune* exulted: DDT "gives every evidence of being as miraculous a substance as the sulfa drugs or penicillin. It is harmless to humans and warm-blooded animals, yet fatal to a wide variety of insects when used in fantastically dilute quantities."[34] Hundreds of similar articles cemented, in the eyes of the public, DDT's reputation as a miracle worker. Federal entomologists noted in 1944 that massive publicity for the army's adoption of DDT, and especially for its use in delousing programs in Naples and North Africa, had created civilian expectations that DDT would solve all pest problems "in houses, gardens, and orchards."[35]

Entomologists regarded these public hopes with delight and trepidation. Although gratified that DDT boosted public appreciation of the significance of insects and entomologists in human affairs, they feared that hopes reached beyond what DDT could deliver. In December 1944, federal entomologist Sievert Rohwer made this point when he reported to the American Association of Economic Entomologists on behalf of a Special Committee on DDT. The committee members concluded that "never in the history of entomology had a chemical been discovered that offers such promise to mankind for relief from his insect problems as DDT." DDT's promise extended to three fields: public health, households, and agriculture. The committee warned, however, that more tests were needed to resolve concerns about DDT's effects on humans and other species, especially in agriculture.[36]

Several factors contributed to the public's lack of knowledge about potential dangers posed by DDT. One was security classification. When Army Surgeon General Norman Kirk asked the National Cancer Institute to study DDT's potential carcinogenicity (discussed in more detail below),

34. Frank Carey, "War Develops Powerful Attack Against Insects," *Mobile Press Register*, 12 December 1943; Walter Adams, "DDT . . . A Deadly New Bug Killer," *Better Homes and Gardens*, May 1944; "Coming: Freedom From Insect Pests," *Reader's Digest*, May 1944; "DDT," *Time*, 12 June 1944; editorial, *Chicago Tribune*, reprinted in *Soap and Sanitary Chemicals*, April 1944, 135.

35. R. C. Roark of the Bureau of Entomology and Plant Quarantine indexed 174 publications on DDT published by June 1944, 418 in the second half of 1944, and 381 more in the first six months of 1945. R. C. Roark and N. E. McIndoo, *A Digest of the Literature on DDT Through April 30, 1944* (Washington, D.C., 1944), 4; R. C. Roark, *A List of Publications on 2,2-Bis(Parachlorophenyl)-1,1,1-Trichloroethane (Called DDT) From 1874 to April 30, 1944, Inclusive* (Washington, D.C., 1944); R. C. Roark, *A Second List of Publications on DDT* (Washington, D.C., 1945); R. C. Roark, *A Third List of Publications on DDT January Through June 1945* (Washington, D.C., 1945).

36. "Report of Special Committee on DDT," *Journal of Economic Entomology* 38 (1945): 144.

OCTOBER
1999
VOL. 40

he asked the institute to keep the topic under wraps. "To avoid disturbing rumors, this office is dealing with this project as a classified (confidential) one," he wrote. "It is trusted that if investigation along this line is approved by your office this same classification will be given to the project."[37]

The way scientists published their findings created a second obstacle. When scientists shared their results in professional journals and meetings, they reached their peers but often not the public. Popular publications, especially those geared to readers with interests in science or conservation, sometimes picked up the story of DDT's potential dangers and spread it to a larger audience. But glowing articles and newsreels about DDT far outnumbered those voicing concerns, and the public came away with the view that DDT was entirely safe. As one user later recalled, "I am a member of a generation that watched newsreels of South Pacific natives being sprayed with DDT and was told that the substance was safe enough to spray right in the room. So we did that at my house."[38]

A third obstacle was the tendency to simplify. Experts saw DDT as a chemical of many faces. It could be used in two major forms (dusts and solutions). It could be dispersed in several ways (dusting cans, aerosol bombs, spray guns, fog machines, and airplanes). It could be used for several purposes (public health, agriculture, and nuisance control). It could be used for varying periods of time (short in wartime, long in civilian agriculture). It could have unintended negative effects on any number of species (people, beneficial insects, fish, birds). Experts argued that different combinations of form, method of dispersal, purpose, and time frame merited separate calculations of dangers and benefits. But complicated views often got simplified, even in professional journals. This 1944 headline from the *American Journal of Public Health* was typical: "DDT Considered Safe for Insecticidal Use."[39]

One of the key points lost in the whirl of publicity was the difference between military and civilian criteria for evaluating DDT, although entomologists tried to impress that point upon journalists. At a press conference on 31 May 1944, F. C. Bishopp implicitly warned that two traits that made DDT ideal for the armed forces—persistence and broad spectrum of activity—were the same traits that gave the Bureau of Entomology and Plant Quarantine pause. In agriculture, a persistent chemical could leave poisonous residues on food, and broad lethality was likely to create pest problems by killing predators and parasites that kept pests in check.[40]

37. Norman T. Kirk and S. Bayne-Jones to Thomas Parran, 26 August 1944, 441 (DDT) July–December 1944, Security Classified General Subject File, RG 112.

38. Edwin Way Teale, "DDT," *Nature*, March 1945, 120; Robert H. Williams, "Spray My Cares Away? I Don't Think So," *Washington Post*, 27 October 1991.

39. "DDT Considered Safe for Insecticidal Use," *American Journal of Public Health* 34 (1944): 1312–13.

40. "DDT Outlook" (n. 27 above).

Pharmacologists, physicians, and fish and wildlife biologists joined entomologists in calling for more testing. All thought DDT promised to improve civilian life, but they wanted to find out how to use the chemical safely before recommending it. Their concern focused on four issues: poisoning from long-term exposure to small doses, carcinogenicity, efficacy in agriculture, and impact on fish and wildlife.

Research at the Food and Drug Administration and the National Institute of Health fueled the concern about long-term exposure to small doses. In a chemical industry journal, H. O. Calvery and his colleagues at the Food and Drug Administration warned in 1944 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. The next year, other Food and Drug Administration scientists reported on the effects of DDT fed to dogs. They found that DDT accumulated in body fat and was excreted in milk.[41] In a technical journal published in July 1944, M. I. Smith and two colleagues from the National Institute of Health described DDT's effects on nerve cells, spinal cords, brains, muscles, kidneys, and livers.[42]

In an article that reached a more general audience, the *Science News Letter* repeated Smith and his colleagues' conclusions: "The toxicity of DDT combined with its cumulative action and absorbability from the skin places a definite health hazard on its use." In laboratory animals, "Small single doses given repeatedly lead to chronic poisoning." Before seeing DDT used in agriculture, "scientists 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."[43]

One of Smith's colleagues at the National Institute of Health, H. B. Andervont, wondered about a particular health hazard: cancer. The publicity DDT received early in 1944 stimulated Andervont's curiosity about this miraculous new chemical, so he undertook "a small exploratory study to ascertain if the compound was carcinogenic." He obtained a sample of

41. John H. Draize et al., "Summary of Toxicological Studies of the Insecticide DDT," *Chemical and Engineering News* 22 (1944): 1503–4, esp. 1504; Arthur A. Nelson et al., "Histopathological Changes Following Administration of DDT to Several Species of Animals," *Public Health Reports*, 4 August 1944, 1009–20; Woodard, Ofner, and Montgomery (n. 6 above), 177–78.

42. R. D. Lillie and M. I. Smith, "Pathology of Experimental Poisoning in Cats, Rabbits, and Rats with 2,2 Bis-Parachlorphenyl-1,1,1 Trichlorethane," *Public Health Reports*, 28 July 1944, 979–84; M. I. Smith and E. F. Stohlman, "The Pharmacalogic Action of 2,2 Bis(P-Chlorophenyl) 1,1,1 Trichlorethane and its Estimation in the Tissues and Body Fluids," *Public Health Reports*, 28 July 1944, 984–93.

43. Jane Stafford, "Insect War May Backfire," *Science News Letter*, 5 August 1944, 90–92, esp. 91; "DDT Warning," *Time*, 7 August 1944, 66.

OCTOBER
1999
VOL. 40

DDT from M. I. Smith, conducted an experiment using "the minimum amount of time and space," and submitted his results in July 1945. These quick tests found no sign that DDT was carcinogenic. But, because "an experiment in which any compound is tested for carcinogenic activity is a major experiment and demands considerable time and space," Andervont did not believe the results were definitive.[44]

An army doctor at Camp Forrest in Tullahoma, Tennessee, also wondered whether DDT might cause cancer. In August 1944 the doctor wrote the army surgeon general that DDT resembled other known carcinogens such as urethane. He urged that DDT's carcinogenicity be assessed "before large scale application of this powerful new insecticide has been undertaken."[45] The doctor's letter provoked a flurry of activity. The surgeon general's office asked M. I. Smith and others at the National Institute of Health whether they had seen signs of cancer in test animals. They answered no, but warned that DDT damaged livers and cartilage in much the same way as a known carcinogen (dimethylaminoazobenzene), so "the possibility cannot yet be excluded that long continued administration of DDT might in some cases lead to liver carcinogenesis." Plus, the head of the Industrial Hygiene Laboratory noted, the solvents in which DDT was dissolved could cause cancer even if DDT itself did not.[46] To resolve the cancer concern, Army Surgeon General Norman Kirk asked the National Cancer Institute to undertake "a special investigation of the possible carcinogenic action of DDT and of the various forms (solutions, powder, etc.) in which it is applied." The head of the institute agreed. He told the army that the tests would likely take two or more years and turned the testing over to Andervont. By the end of the war, the cancer question remained open.[47]

Physicians, pharmacologists, and industrial hygienists worried mainly about the effect of DDT on people. In addition to this concern, entomologists worried about DDT's effect on crops, beneficial insects (e.g., honey-

44. H. B. Andervont to Dr. Spencer, 8 April 1946, attached to John W. Regan to R. R. Spencer, 2 May 1946, 441 (DDT) 1946, General Subject File, RG 112.

45. Ludwik Gross to the Surgeon General, U.S. Army, 17 August 1944, 441 (DDT) July–December 1944, Security Classified General Subject File, RG 112.

46. Dunn to Neal, 23 August 1944; Smith and Lillie to Neal, 22 August 1944; and Fraser to Kirk, 24 August 1944 (all n. 6 above).

47. Norman T. Kirk and S. Bayne-Jones to Thomas Parran, 26 August 1944, and Thomas Parran to Norman T. Kirk, 1 September 1944, 441 (DDT) July–December 1944, Security Classified General Subject File 1938–44, RG 112. Unfortunately, Andervont did not do the study. Asked for results in 1946, Andervont said he thought the army's DDT samples arrived in September 1944, but his assistant was ill and soon died. Because "an experiment in which any compound is tested for carcinogenic activity is a major experiment and demands considerable time and space," Andervont decided to undertake no new studies until he had a healthy assistant. A new assistant started in March 1945, but Andervont still found no time for the army study. Andervont to Spencer, 8 April 1946. In 1946, an embarrassed head of the National Cancer Institute reported Andervont's lapse to the army and ordered that tests begin. R. R. Spencer to S. Bayne-Jones, 8 April 1946.

bees), and animals. Initial tests showed that DDT could damage all three.[48]

The impact on beneficial insects was ironic: trying to kill pests, entomologists believed, could worsen pest problems. One study found a sixfold 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 predatory lady beetles were killed. In experiments in Indiana, spraying DDT for codling moths had led to increased populations of mites and aphids. In the Pacific Northwest, spraying led to marked increases in woolly aphids and promoted canker. Most of the sprayed trees dropped their leaves prematurely, and fruit size seemed to suffer. The Bureau of Entomology and Plant Quarantine's Sievert Rohwer concluded that "irrespective of the residue problem the Bureau does not feel justified in recommending the use of DDT insecticides for codling moth control." This was an important statement, for codling moths and boll weevils created the two largest markets in the United States for insecticides.[49]

More broadly, entomologists wondered whether DDT might wipe out all life when broadcast over large areas. These concerns were not based on idle speculation but on field tests. After experiments in Panama, the Bureau of Entomology and Plant Quarantine's H. H. Stage and C. F. W. Muesebeck wrote: "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." 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."[50]

48. "DDT is Dynamite to Insects But Effect on Man is Doubted," *Washington Post*, 10 July 1944; Roark and McIndoo (n. 35 above).

49. E. Bishop to O. R. McCoy, 13 September 1944, 441 (DDT) July–December 1944, General Subject File, RG 112; Frederick S. Philips, "Medical Division Report No. 13, A Review of the Biological Properties and Insecticidal Applications of DDT," 22 November 1944, 2, U.S.A. Typhus Commission—DDT—General, U.S.A. Typhus Commission, RG 112; Summary, Joint Meeting of DDT Producers and Arsenical Producers Industry Advisory Committee, 19 October 1944, 9–10, 535.61105, Policy Documentation File, Record Group 179: War Production Board, National Archives and Records Administration, Washington, D.C. (hereafter cited as RG 179); Perkins, *Insects, Experts* (n. 2 above), 15–22, 40–44.

50. H. H. Stage and C. F. W. Muesebeck, "Insects Killed by DDT Aerial Spraying in Panama," National Research Council Insect Control Committee Report No. 108, 1 July 1945, 1, OSRD Insect Control Committee Reports—Numbered—Volume II, Committees on Military Medicine, Division of Medical Sciences, NRC; Minutes, Joint Meeting of the

OCTOBER
1999
VOL. 40

Reports on DDT use in the Pacific lent credence to these concerns. Leroy Christenson, an entomologist and captain in the U.S. Army Sanitary Corps, reported in January 1944 that DDT killed all "small fish, crabs, and all types of immature insects such as dragon fly, damsel fly, and chironomid (midge) larvae." A British report commented on the same phenomenon; twenty-four hours after spraying, researchers found dead prawns, fish, dragon flies, and caterpillars. Naval medical personnel later reported that overdoses of DDT on Espiritu Santo, an island in the New Hebrides, resulted in "complete destruction of plant and animal life."[51]

Fish and wildlife biologists shared the concern about DDT, especially when broadcast over large areas. 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.[52] The Fish and Wildlife Service conducted tests at Patuxent River Refuge in Maryland during the summer of 1945. These tests found that even small doses of DDT (one half pound per acre) killed fish, and larger doses (five pounds per acre) "drastically reduced" bird populations as well. These experiments seemed important enough that Robert F. Griggs, chair of the National Research Council's Division of Biology and Agriculture, journeyed to Patuxent to look at them firsthand. He concluded that the Patuxent project leaders showed "thoroughness and vision."[53] Colonel J. W. Scharff, a British malariologist who praised the role of DDT in protecting troops from malaria, found such effects acceptable in war but not in peace. "As an entomologist and lover of nature," he said, "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

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OSRD Insect Control Committee and the Army Committee for Insect and Rodent Control, 6 April 1945, 3, Insect Control, Misc. Minutes and Conferences, Committee on Insect Control (OSRD), Committees on Military Medicine, Division of Medical Sciences, NRC.

51. Leroy D. Christenson to Surgeon, HQ USAFISPA, 3 January 1944, 441 DDT through 30 June 1944, Security Classified General Subject File, RG 112; British reports attached to Headquarters, Supreme Allied Commander, South East Asia, to various offices, 4 October 1944, 441 (DDT) July–December 1944, Security Classified General Subject File, RG 112; Comments by Capt. J. J. Sapero, Lt. B. V. Travis and Comdr. H. P. Hopkins in Minutes, Subcommittee on Dispersal, 18–19 February 1946, 18, Miscellaneous Minutes and Conferences, Committee on Insect Control (OSRD), Insect Control, Minutes (Bulletins) and Reports, Committees on Military Medicine, Division of Medical Sciences 1940–1945 [discrepant dates in original], NRC.

52. Minutes, Joint Meeting of the National Academy-Research Council Insect Control Committee and the OSRD Insect Control Committee, 2 May 1945, 2, Joint with N.A.S., Committee on Insect Control, Executive Board, Administration, NRC.

53. Emory C. Cushing, "Report of Visit of Swiss Scientists," 24 September 1945, 4, 441.(DDT) July–December 1945, General Subject File, RG 112; Robert F. Griggs to M. C. Winternitz, 15 June 1945, Committee on Insect Control, OSRD, Office of Emergency Management, Executive, Government, N.A.S.-NRC Central File, NRC.

the routine use of this material from the air with anything but horror and aversion."[54]

In April 1945, the army and the U.S. Public Health Service acted on these concerns when they announced restrictions on domestic use of DDT. At the time, the War Production Board's priority system gave these two agencies virtual hammerlocks on nonexperimental use of DDT in the United States. Military demand still outstripped supply, so the board allowed manufacturers to sell DDT only to the federal government for military and experimental use. The Public Health Service's activities fell into the military category because it ran the Malaria Control in War Areas project, which protected soldiers on bases and workers in defense factories from malaria.

These two agencies decided to protect what would later be called "the environment" from potential harm by banning aerial spraying except in exceptional cases. (They allowed use on smaller scales, such as by dusting individuals or spraying rooms.) "Much still must be learned about the effect of DDT on the balance of nature important to agriculture and wild life before general outdoor application of DDT can be safely employed in this country," the press release stated.[55] A special army committee (with advisors from the Public Health Service, Bureau of Entomology and Plant Quarantine, and Fish and Wildlife Service) reviewed all requests for aerial spraying of DDT inside the United States. As of 8 August 1945 the committee had approved only seven projects, all on military bases.[56]

These two agencies also argued that, in their eyes, different criteria should govern military and civilian evaluations of the costs and benefits of technology. Soldiers overseas faced a high risk of serious disease and short exposure to DDT, while civilians faced a lower risk of disease and long exposure to DDT. On battlefronts, where destruction reigned, killing birds or fish seemed trivial. At home, where livelihoods and recreation depended on "the balance of nature," killing beneficial insects, fish, and birds carried a higher price. As the April 1945 press release announcing restrictions put it, "It may be necessary to ignore these considerations [of the balance of nature and impact on wildlife] in war areas where the health of our fight-

54. Minutes, Special Joint Meeting of the Army Committee for Insect and Rodent Control and the Office of Scientific Research and Development, Insect Control Committee, 12 January 1945, 7, Report No. 39, OSRD Insect Control Committee Reports v. 1, Minutes (Bulletins) and Reports, Committees on Military Medicine, Division of Medical Sciences, NRC; Harriet Geer and Herbert Scoville Jr., "Methods of Dispersal of DDT," 1 March 1945, 2, Committee on Insect Control, OSRD, Office of Emergency Management, Executive, Government, N.A.S.-NRC Central File, NRC.

55. "Use of DDT for Mosquito Control in the United States" (n. 6 above); Humphreys (n. 2 above).

56. Ahnfeldt to Surgeon General, 7 July 1945; Ahnfeldt to Annand, 7 July 1945; Ahnfeldt to Gabrielson, 7 July 1945, McCoy and Hart to Lincoln, 8 August 1945 (all n. 6 above).

OCTOBER
1999
VOL. 40

ing men is at stake, but in the United States such considerations cannot be neglected."[57]

The army and the Public Health Service may have felt that no one could ignore these considerations, but they would not decide DDT's long-term fate. In the short run their policies amounted to de facto federal policy because they controlled most DDT used in the United States. And over the next several months, the amount they used (mostly overseas) soared. In June 1945, manufacturers churned out an astounding three million pounds of DDT per month, up from none in 1942 and 193,000 pounds in all of 1943.[58]

But this tidal wave of production eroded the authority of the army and the Public Health Service and gave more control over DDT's fate to the War Production Board, which oversaw production of DDT and other materials of military value. So long as military demand outstripped supply, the board required producers to sell all their DDT to the federal government, which in turn decided how to use the chemical. But by July 1945 the War Production Board thought a small surplus of DDT over military needs would appear in the fourth quarter of 1945.[59] This surplus gave the War Production Board the freedom to allow sales of DDT to civilians to control insects in homes and on farms. Freedom for the War Production Board amounted to freedom for DDT manufacturers. The board (made up of industry representatives temporarily working for the government) usually followed the advice of its chemicals division (made up of chemical company managers temporarily working for the government), which usually accepted the advice of its DDT Producers Industry Advisory Committee (made up of representatives of companies that made DDT and its precursors).[60]

The DDT Producers Industry Advisory Committee decided how manufacturers would handle the surplus on 25 July 1945, when they met with representatives of the War Production Board chemicals division and members of the Bureau of Entomology and Plant Quarantine. They knew that entomologists were still not ready to recommend DDT for all uses in agriculture, the market in which producers were most interested. The Department of Agriculture's G. F. McLeod listed four criteria by which to judge DDT's suitability: the U.S. Bureau of Entomology and Plant Quarantine or experiment station officials should determine that DDT was effective against a given pest; considerable loss should occur if DDT were not used;

57. "Use of DDT for Mosquito Control in the United States"; Humphreys. On ways in which World War II encouraged entomologists to shift from biologically based to chemically based methods of pest control, see Perkins, "Reshaping Technology," (n. 2 above).

58. J. Solon Mordell to George K. Hamill, 20 July 1945, 535.61105, Policy Documentation File, RG 179.

59. Ibid.

60. Summary, DDT Producers Industry Advisory Committee, 25 July 1945, 3–4, 535.61105, Policy Documentation File, RG 179.

DDT should "leave no deleterious residue"; and DDT should not poison bees or upset "the biological complex."[61]

The makers of DDT disagreed among themselves on how to respond to these concerns. One manufacturer asked the War Production Board to "hold rigid control" over DDT until a greater surplus had accumulated and federal and state officials had developed guidelines for safe and effective use. He feared "chaotic miscellaneous public demand and use," which would be dangerous since "we have not yet established the safety controls." On the other hand, "[o]ne or two industry representatives" wanted the freedom to sell to civilians all the DDT they could make beyond military requirements.[62]

The latter view won out. As soon as "a considerable surplus" existed, the War Production Board decided, it would allow companies to sell DDT to anyone in any quantity.[63] Surviving records do not tell us the reasons for the decision, the method used to decide, nor which representatives held which views. But the decision served the interests of the manufacturers who wanted to sell, and it followed more than it broke with regulatory tradition and War Production Board policies.

Under the pre–World War II regulatory system, no government agency had the authority to keep pesticides off the market. The Department of Agriculture had the power to enforce labeling requirements, and the Food and Drug Administration had the authority to seize foods with pesticide residues above specified levels. But neither agency had the power to stop a company from selling an accurately labeled chemical.[64] Moreover, the War Production Board had announced that it wanted to avoid surpluses and would make conversion to civilian use a priority. (After World War I, the United States had cut back sharply on military production with little provision for switching to civilian production, and the country tumbled into depression.) The DDT producers' decision followed that policy.[65]

With that decision, DDT entered its second regulatory phase, in which the market governed DDT sales. (At the beginning of this phase the War Production Board had the authority to limit DDT sales but delegated deci-

61. In addition to these four, McLeod listed three more that were specific to World War II and the "end use" system in effect: the crop or animal must be important in the food production program; no other insecticide could serve; and the person recommending the use DDT should keep track of that use. The Department of Agriculture wanted to wait until the results of that summer's experiments were in before making a recommendation. Summary, DDT Producers Industry Advisory Committee, 25 July 1945, 3–4.

62. Ibid.

63. Ibid.

64. Dunlap (n. 2 above); Whorton (n. 10 above).

65. Summary, DDT Producers Industry Advisory Committee, 25 July 1945, 4; John Rodda, "The Outlook for Insecticide Raw Materials," *Soap and Sanitary Chemicals*, October 1944, 109–10.

sions to companies. Once the board went out of business, no government agency held such authority.) The Bureau of Entomology and Plant Quarantine's Sievert Rohwer tried to impress upon industry leaders the significance of this shift in control at the meeting in which they made their decision. He told them that "the producers of DDT will have a great responsibility as well as an opportunity. He expressed the hope that they would use their opportunity wisely. He stressed that there was a great deal that was still unknown on how to formulate DDT insecticides so they could be used safely, effectively, and to the interest of the user and the public good."[66]

Acting on DDT producers' advice, the War Production Board released DDT for sale to the public in August 1945. At first, market forces limited sales by leading risk-averse manufacturers, which tended to be the larger companies, to factor in the cost of potential lawsuits and hold off on sales. But smaller companies, apparently less daunted by the risk, went to market. As it turned out, DDT did not produce much visible, short-term damage, and the larger companies followed the small ones into the market. Sales soared.[67] In marketing DDT manufacturers capitalized on DDT's role as military hero and omitted mention of potential harm to people or wildlife (fig. 1).

In 1972 DDT entered its third regulatory phase. By then, some scientists believed that DDT and other pesticides did cause significant harm to beneficial insects and wildlife, and they feared it might cause cancer in people. Scientists and activists gathered knowledge, mobilized citizen groups, lobbied Congress, and used the legal system to influence policy. In that year the Environmental Protection Agency banned sales of DDT in the United States. However, the policy allowed companies to make DDT in the United States for sale abroad for any use, and to sell it in the United States for quarantine and public health purposes.[68]

Unaware of the chemical's complicated career in World War II, most people saw this third phase as radically new. In fact, this phase returned the chemical to virtually the same position it had occupied during the war. In both periods the chemical was made in the United States and used over large areas overseas; at home its use was permitted to protect public health, but because of concerns about wildlife large-scale use in agriculture was banned. Between these two phases the capacity and willingness of the state to develop and act upon the views of experts espousing "environmental" values declined. (Other factors also played roles: the relative power of industry and various government agencies, the influence of interest groups, a growing commitment of entomologists and farmers to pesticides, and

66. Summary, DDT Producers Industry Advisory Committee, 25 July 1945, 5.

67. "WPB Lifts Restrictions on DDT," *Soap and Sanitary Chemicals*, August 1945, 125; "DDT Insecticides Rushed on Market," *Soap and Sanitary Chemicals*, September 1945, 124A–124C, esp. 124A; Dunlap, 65.

68. Dunlap, 234.

congressional willingness to pass enabling legislation.)[69] These findings reinforce the view that World War II marked a watershed in federal government capacity. The prewar administrative state had responded to problems; the proministrative state defined and tried to solve problems in advance of public opinion.

* * *

DDT's surprisingly complicated history during World War II adds to our understanding of the values guiding scientific evaluation. It shows that "environmental values" influenced government scientists well before the rise of the modern environmental movement, and that the United States traveled two routes, separated by a quarter century, to federal limits on use of technology for environmental reasons.

This story also illustrates the importance of reciprocal interactions between warfare (or military institutions) and civilian life. Scholars have not devoted so much attention to this interaction as to others. Peter Paret has noted that "academics have considered war as something exceptional, a crisis . . . and therefore not suited to constitute one of the units into which we organize research and teaching." Perhaps we share the American tendency to, as one writer put it, "see peace and war as two totally separate quanta. War is abnormal and peace is normal and returns us to the status quo ante."[70] With historians of technology among the leaders, scholars have produced a great deal of evidence challenging the view that military and civilian spheres have had little impact on each other. This study confirms one of the common points in this literature: product testing and development has been one of the most important ways that the armed forces have influenced civilian technology.[71] Before DDT went to market, federal experts conducted extensive testing of its safety and efficacy at no cost to manufacturers. In Orlando alone, twenty-nine researchers worked "unheard of" hours on DDT. The Orlando laboratory spent about $1 million during World War II, much of it on testing DDT.[72]

The career of DDT also illustrates war's impact on civilian supply and demand. The War Production Board put a dozen companies into the busi-

69. For detailed discussion, see the references in n. 2 above.

70. Peter Paret, "The New Military History," *Parameters* 21 (autumn 1991): 10–18, esp. 12; Joseph A. Wildermuth, "Bad Company," letter to *Washington Post Book World*, 20 February 1994, 14.

71. Merritt Roe Smith, ed., *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge, Mass., 1985); Alex Roland, "Technology and War: The Historiographical Revolution of the 1980s," *Technology and Culture* 34 (1993): 117–34; Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, Mass., 1996).

72. Geigy Company Inc., New York, "Now It Can Be Told," [n. d.], U.S.A. Typhus Commission DDT—Publicity, U.S.A. Typhus Commission, RG 112; Baxter (n. 12 above), 363.

ness of making millions of pounds of DDT per month, and those companies wanted to sell even larger amounts to civilians after the war. According to Army Surgeon General Norman Kirk, Du Pont refused to begin manufacturing DDT until guaranteed a license from Geigy to sell DDT after the war, a demand that temporarily had slowed the expansion program.[73]

How do we explain the slippage between expert awareness of DDT's problems and the public's view that DDT promised to work only miracles? The lack of government mandate to regulate is one factor, as we have seen, but there are others. Wartime publicity, which expressed genuine enthusiasm for DDT but also illustrated efforts by government and private officials to keep civilian morale high, played a large role. Civilians impressed by wartime publicity clamored for the new miracle chemical. As a speaker at a meeting of DDT producers put it in July 1945, "the general public has been led to believe that DDT will perform miracles under all circumstances." Industry officials credited the army and navy with creating a far larger market for their products than would otherwise have existed. Lawrence Killilea, a Hercules manager, believed that "it is only within the past war years that the American people have become insecticide conscious and this has been largely due to insistence by the Army and Navy that our troops should not fall prey to typhus, malaria, and other insect-borne diseases."[74]

Increased civilian demand for a military product resulted not just from efforts of the armed forces, but from the climate of war. Most of DDT's publicity came from newspapers, magazines, and newsreels; they publicized DDT far beyond what the armed forces or industry could have financed on their own. As the National Association of Insecticide and Disinfectant Manufacturers noted: "BUGS! Bugs! Bugs! All through the war, bugs and how to kill them received a billion dollars worth of publicity,—every dollar of it a mighty valuable sales asset to the insecticide industry."[75]

The general rhetoric of scientific and technological miracles flowing from World War II played a role in simplifying DDT's image as well. The promise of penicillin, plasma, plastics, and even algae burgers flooded newspapers and the airwaves as the nation embraced the idea that science and technology, which had proved their ability to help wreak destruction on a previously impossible scale, would also solve problems on as wide a scale.[76]

73. By May 1945, DDT producers included General Chemical, Pennsylvania Salt, J. T. Baker, Monsanto, Cincinnati Chemical Works (partly owned by Geigy), Michigan, Du Pont, Merck, Hercules, Westvaco, and Marietta Dyestuffs. Summary, DDT Producers Industry Advisory Committee, 8 May 1945, 535.61105, Policy Documentation File, RG 179; Norman T. Kirk to Commanding General, Army Service Forces, 29 December 1943, 441 (DDT) through 30 June 1944, Security Classified General Subject File, RG 112.

74. Minutes, DDT Producers Meeting, 18 July 1945, 7, 535.61105, Policy Documentation File, RG 179; "Testing Thanite," *Hercules Mixer* April 1946, 118.

75. "Sanitary Products," *Soap and Sanitary Chemicals*, March 1946, 121.

76. Warren Belasco, "Algae Burgers for a Hungry World? The Rise and Fall of Chlorella Cuisine," *Technology and Culture* 38 (1997): 608–34.

OCTOBER
1999
VOL. 40

In an era of enthusiasm for dual-use technology, DDT's career reminds us that military technology has not always suited civilian needs.[77] When the Commissioner of Food and Drugs suggested in 1949 that the United States restrict DDT in milk because of health dangers, he had to remind Americans that there "wasn't any question, even in those war years, but that DDT was poisonous." Use of DDT in World War II had been a "reasonably calculated military risk," he said, because short exposure to DDT created a smaller risk for soldiers than did typhus and malaria. But a different calculus should hold in peace, because long-term exposure to small doses might have a "cumulative effect." Unfortunately, the commissioner noted, "the public has come to believe that it is not poisonous."[78]

The public view and federal policy would eventually change. By the time they did, no one seemed to remember that these changes revisited values and regulatory approaches seen more than two decades earlier.

77. David F. Noble, "Command Performance: A Perspective on the Social and Economic Consequences of Military Enterprise," in Smith, *Military Enterprise and Technological Change* (n. 71 above), 329–46, esp. 330–31.

78. Paul B. Dunbar, "The FDA Looks at Insecticides," *Food Drug Cosmetic Law Quarterly*, June 1949, 234–39, esp. 236.