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A TECHNOLOGY ASSESSMENT

OF THE

VIETNAM DEFOLIANT MATTER

A CASE HISTORY

REPORT

TO THE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES

NINETY-FIRST CONGRESS
FIRST SESSION

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AUGUST 8, 1969

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Author
F. P. Huddle

LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., August 8, 1969.

Hon. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: The Subcommittee on Science, Research, and Development is carrying on a continuous study of technology assessment—seeking the best means of providing for the Congress an early warning of the unanticipated hazards or benefits from applications of science.

The process of technology assessment can best be seen with reference to historical episodes, but the record of such episodes is often incomplete. If we are to secure a useful working knowledge of the elements of the process, it is expedient for us to take opportunities to observe closely those episodes which chance makes accessible. It was for this reason that the subcommittee commissioned the study "Technical Information for Congress" by the Science Policy Research Division—a documentation of 14 important case histories which had attracted congressional attention since World War II.

This report is a 15th case history. It has special significance for Congress in the technology assessment context, since it represents a conflict which is current but which has developed a sufficient history to give it perspective and meaning. It is distinguished from the other case histories in that the assessment was performed by the scientific community itself, and outside of the Halls of Congress.

We are dealing here with the controversy over the military use of chemical defoliants and herbicides in Vietnam. The issue contains all the elements that complicate such assessments: a difficult problem of ecological impact, clouded by the political controversy surrounding the Vietnamese conflict itself.

The report transmitted herewith does not address itself to the merits of the issue; it does not judge the propriety or impropriety of the military use of herbicides. Instead, it centers upon the process by which the American Association for the Advancement of Science undertook to assess the ecological effects of the military use of chemical defoliants and herbicides in a zone of activity. The cooperation of the participants in the assessment was, of course, indispensable to the study, and we were most fortunate that they fully appreciated the professional nature of the proposed inquiry and were unstinting in providing the documentation for it.

At my direction, the Legislative Reference Service secured the status of observer to the proceedings. From this vantage point the study is

ssessment in a [illegible]hat can guide similar projects in the future. It vill aid the variou[illegible] groups who are developing technology assessment apabilities for the legislative branch, and in other institutions.

Sincerely yours,

EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development.

LETTER OF SUBMITTAL

THE LIBRARY OF CONGRESS,
LEGISLATIVE REFERENCE SERVICE,
Washington, D.C., July 30, 1969.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. DADDARIO: The report submitted with this letter results from arrangements made at your direction to follow the progress of the American Association for the Advancement of Science in its investigation of the environmental effects of defoliation in Vietnam. Mr. Richard A. Carpenter, Assistant Chief of our Science Policy Research Division, sought permission from the major participating organizations in early 1967, for LRS to act as an observer of the assessment process as it took place. In this way, the problems and successes of assessment methodology could be more accurately ascertained than by the usual ex post facto examination. We, of course, made it clear to all parties that the LRS had no interest in the defoliation-ecology question itself but only in how the assessment was carried out.

The cooperation of the following persons and their associates made the report possible:

Don K. Price, dean, John Fitzgerald Kennedy School of Government, Harvard University.
Dr. Dael Wolfle, American Association for the Advancement of Science.
Rodney W. Nichols, Office of the Director of Defense, Research and Engineering.
Dr. William B. House, Midwest Research Institute.
John S. Coleman, National Academy of Sciences.

The report was written by Franklin P. Huddle, of the Science Policy Research Division. In view of Dr. Huddle's earlier authorship of the study, "Technical Information for Congress," the present report can be regarded as in a sense supplementary to that longer work, dealing with a similar kind of problem but in the hands of a distinctly different group.

The Legislative Reference Service is gratified to have the opportunity to participate in this illuminating series of analyses of the complex problem of accommodating our society to the changes wrought by modern science.

Sincerely yours,

LESTER S. JAYSON,
Director, Legislative Reference Service.

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I. INTRODUCTION

A new military technology of defoliation by aerial spraying of herbicidal chemicals was introduced in 1962 into the Vietnam conflict. The technology was called into play as a means of saving lives—protecting troops, shipping, and aircraft from ambush from the jungle cover; it was also used to complicate the adversary's logistics—to deny guerrillas their sources of food from remote garden plots by the spraying of these crops from the air with crop-destroying chemicals. These uses of technology were condemned as immoral by virtue of their nonspecificity; as contravening tacit international policy against chemical and biological warfare, as crossing a threshold beyond which lay the threat of mass destruction by chemical and biological weapons; they were also challenged on the more technical grounds that the generous use of these potent chemicals over wide areas by insufficiently trained military personnel might wreak serious and lasting injury to a region's ecology.

The role of U.S. scientists and their professional organizations in calling for technological assessment of military uses of herbicides, and in participating in such an assessment, was determined by Representative Emilio Q. Daddario as being a suitable subject for this study. Its purpose, accordingly, was not intended as a judgment of the merits of the decision respecting military use of herbicides, but to illuminate the complicated process within a large, interdisciplinary organization of scientists by which a political issue with a scientific content was passed in review. Many such issues come before the American Association for the Advancement of Science. Activist groups continually strive to compel the association to take a stand on other political issues they care deeply about. The effectiveness of the association as a policy-supporting organization, and the question as to the proper role of scientists in pursuing political issues, are central elements of the study.

The relevance of the study as a subject of interest to the Congress derives from a number of related considerations. In it, the Congress can find its function of technology assessment being attempted by a group of concerned citizens, mostly with scientific qualifications. The problems encountered by this group in performing its assessment can be regarded as "the other side of the coin." The pressures and thought processes of the group mirror those of the Congress, and provide a convincing demonstration of the difficulties of the task, even when it is not accompanied by the larger responsibility of the Congress for lawmaking in the public interest, and when, on the other hand, the participants enjoy some extent of special training in the subject matter in question.

Another relevant aspect is the preoccupation of the Congress in 1969 with environmental quality. Much pending legislation, and many

32-465—69——2

... other his[illegible]o man's fragile environment. The difficulties encountered by a p[illegible]essional group in ordering and resolving environmental issues related to the massive and repeated application of herbicides in Vietnam serve a useful warning and object lesson as to the need for systematic, objective, and deliberate approaches on the part of the Congress in dealing with legislation aimed at the preservation or restoration of environmental quality in the United States.

In the study "Technical Information for Congress," [1] it was pointed out that "In the management of a political issue with substantial scientific or technological content, the political issue is always larger in scope than the scientific question within it." The study suggested that "In principle, the scientific question needs to be dealt with first." Moreover, it was important that the scientific question be "carefully framed so that the answer to it provides a useful and significant piece of evidence for guidance in the consideration of the broader political issue." The present study enlarges indirectly on this point by revealing the extreme difficulty encountered by a technically oriented group in separating out the technical issue, and defining it in manageable terms. It proves notive, by inference, that a politically oriented group would experience even greater difficulty in separating the technical from the political issue for analysis and decision.

Development of Potent New Organic Herbicides

Agricultural research in the 1930's had identified a group of plant hormones that regulated plant growth. By 1939, 54 different substances were listed that had this effect. The most powerful of these was the chemical 2,4-dichlorophenoxyacetic acid, later nicknamed "2,4-D." The chemical synthesis of this compound was described in the literature in June 1941. Experimenters often observed that an overdose of one of these plant hormones injured and even killed plants. One researcher, E. J. Kraus, head of the botany department of the University of Chicago, suggested in a letter to two of his coworkers, in August 1941, that these compounds might be useful as weed killers.

Early results in his researches led Kraus to bring this promising new technology to the attention of a committee of the National Academy of Sciences-National Research Council under the direction of George Merck, established at the request of Secretary of War Henry L. Stimson to provide advice on all aspects of biological warfare. Kraus wrote that "the toxic properties of growth-regulating substances for the destruction of crops or the limitation of crop production" might be of interest to the committee. Experimental research in this field continued early 1942. It was formally brought under an Army contract with the University of Chicago, in 1943. In conjunction with this work, a research program was also underway at the research station of the U.S. Department of Agriculture, at Beltsville where John W. Mitchell, a student and associate of Kraus, in March 1944, began testing the effec-

[1] U.S. Congress. House. Committee on Science and Astronautics. Technical Information for Congress. Report to the Subcommittee on Science, Research and Development of ... Prepared by the Science Policy Research Division, Legislative Reference Service, Library of Congress. (Committee Print), Serial A, Apr. 25, 1969. 91st Cong. 1st sess. (Washington: U.S. Government Printing Office, 1969.) (See especially p. 506.)

[illegible] During the later stages of the Pacific war, interest [illegible] was intensified as of possible use in the "island-hopping" campaign of Gen. Douglas MacArthur. The method of clearing landing areas of foliage at that time was by saturating them with high explosive shell bombardment by naval artillery. Kraus reported verbally on his research progress to the "ABC" Committee of the Academy of Sciences in February 1943, and submitted a preliminary written report to the committee March 8, describing his experiments. Camp Detrick, Md., had been establish as a research center for biological warfare research in November 1942; in January 1944, the Army decided to make herbicide research a major program at this center. Nearly 1,100 substances were tested there, under the direction of Kraus with A. G. Norman. However, "The chemicals were never used abroad, and the war terminated before we could get the materials in the field." [2]

At the conclusion of World War II, Secretary of War Robert P. Patterson released a letter report from Merck, describing biological warfare research conducted by the United States. Merck cited as an important accomplishment of this program, the testing of "the effects of more than 1,000 different chemical agents on living plants." Later Merck was quoted as stating that "only the rapid ending of the war prevented field trials in an active theater of synthetic agents that would, without injury to human or animal life, affect the growing crops and make them useless."

In April, 1944, the emphasis of the research at Beltsville shifted. Detrick had a vigorous, war-oriented program underway. So the Beltsville group returned to their earlier interest in 2,4-D as a weed killer. In June 1944, in an article in the Botannical Gazette, Mitchell, in association with Charles L. Hamner (another former student of Kraus), suggested publicly for the first time that 2,4-D had "some importance in connection with the differential killing of weeds." [3] Another report in this journal in December 1944 elaborated on this work. The chemical was found highly toxic to bindweed, dandelion, and other broadleafed plants, while leaving lawns (bluegrass) unharmed. The public interest in the new herbicide was intense. In 1945, the American Chemical Paint Co. marketed the first systemic herbicide under the brand name "Weedone." Other companies were soon licensed to produce the material. Tests that year revealed that the new chemical was indeed a revolutionary discovery. The toxicity level of the new chemical, for man and animals was investigated, and determined to be low enough to make the chemical acceptable for general use as a weed killer. Lists of weeds killed by 2,4-D lengthened. Costs dropped from $12.50 a pound in 1944 to $0.50 a pound in 1950. The material was easy to handle, noncorrosive, and effective in use. Production went up fast: 917,000

[2] C. E. Minarik, "Crop Division Defoliation Program," Proceedings of the Third Defoliation Conference, Aug. 10-11, 1965, p. 11. The rest of this account is based on an article by Gale E. Peterson, "The Discovery and Development of 2,4-D", Agricultural History (vol. 41, No. 3, July 1967).

[3] "Polyethylene Glycols as Carriers for Growth-Regulating Substances," Botannical Gazette, (Vol. CV, June 1944), p. 482.

-ounds in 1945, 5,466,000 in 1946, and more than 14 million by 1950. he author of thi[s] ory concluded:

Ironically, 20 ye[ars] r Kraus had suggested it to the National Academy of ciences, 2,4-D becam[e] a tool of chemical warfare, * * * Developed for war, t designed for agriculture, the U.S. military at last found application for its ntribution to the development and testing of 2,4-D.[4]

A survey of the domestic use of herbicides in the United States, con-ucted by the Department of Agriculture, reported in August 1965, at in the year 1962 a total of 70 million acres was treated (see table), at a cost of more than $270 million. The report note that by 1962, bout 100 herbicides in 6,00 formulations were available. The rate of creased use was such that acreages treated would continue to double 10 years. (Actually, they leveled off at about 120 million acres by 70.)

BLE 1.—ESTIMATED EXTENT AND COST OF CHEMICAL WEED CONTROL IN THE UNITED STATES, 1962

Crop or area	States reporting (number)	Total acreage treated (thousands)	Harvested acreage treated (percent)	Total cost, all herbicides and applications (thousands)	Average cost per acre, all treatments
[illegible]	46	25,302	38.8	$57,600	$2.28
[illegible]	15	5,433	34.9	16,805	3.09
[illegible]	28	2,827	10.2	10,835	3.83
[illegible]	45	18,931	23.5	29,579	1.56
[illegible]	6	940	53.0	6,250	6.65
[illegible]	8	310	22.0	2,565	8.27
[illegible]	15	362	32.8	2,237	6.18
[illegible]	25	2,665	23.1	5,258	1.97
[illegible] seeds	20	439	16.1	2,416	5.50
[illegible]	29	951	35.5	8,638	9.09
[illegible]	4	171	12.4	1,017	5.95
[illegible]	2	16	1.1	114	7.12
[illegible]	1	30	4.6	187	6.23
[illegible]	1	26	27.0	650	25.00
[illegible] fruits and nuts	21	267	9.7	2,397	8.98
[illegible] berries	15	51	24.8	969	19.00
[illegible]	23	672	8.4	15,368	22.86
[illegible]	33	412	.6	1,794	8.69
[illegible]	45	4,714	1.5	13,340	2.83
[illegible]land	20	2,262	.3	6,265	2.77
[illegible] plantings	18	274	.....	2,752	10.04
[illegible]cropland	31	3,612	.....	83,714	23.18
Total	50	70,667	5.4[illegible]	270,746	3.86

Excludes forest plantings and noncropland.

Source: U.S. Department of Agriculture, Agricultural Research Service and Federal Extension Service. "Crops Research; rvey of Extent and Cost of Weed Control and Specific Weed Problems." (Aug. 1965, ARS 34-23-1), p. 3.

cond Thoughts About the Virtues of Herbicides and Other Pesticides

The explosive rate of acceptance of the new technology eventually ve rise to apprehensions as to its possible adverse side effects. A tech-logical assessment of the domestic use of herbicides—and of pesti-les in general—was triggered by the appearance in 1962 of an influ-tial popular book by Rachel Carson, titled "Silent Spring." This ok described disadvantageous consequences of pesticides, including possibility of the toxicity of some of them to man or animals, their ssibly long-term biological (e.g., pathogenic, carcinogenic, and tagenic) effects, and the ways in which pesticides reached beyond their intended target organisms to strike down others m[illegible]eful if sometimes insufficiently appreciated. This last type of eff[illegible]e eco-logical damage caused by pesticides—was emphasized by [illegible] Carson book. Although Miss Carson reserved her most severe criticisms for insecticides, she did not spare the weedkillers:

> The legend that the herbicides are toxic only to plants and so pose no threat to animal life has been widely disseminated, but unfortunately it is not true (p. 41).
>
> [Aminotriazole] is rated as having relatively low toxicity. But in the long run its tendency to cause malignant tumors of the thyroid may be far more significant * * * (p. 43).
>
> Among the herbicides are some that are classified as 'mutagens," or agents capable of modifying the genes, the materials of heredity. We are rightly appalled by the genetic effects of radiation; how, then, can we be indifferent to the same effect in chemicals that we disseminated widely in our environment? (p. 43.)
>
> * * * The whole closely knit fabric of life has been ripped apart (p. 67).
>
> [By this "shotgun approach to nature"] the spraying also eliminates a great many plants that were not its intended target (p. 67).
>
> * * * The wholesale broadcasting of chemicals would be seen to be more costly in dollars as well as infinitely damaging to the long-range health of the landscape and to all the varied interests that depend on it (p. 69).
>
> The most widely used herbicides are 2,4–D, 2,4,5–T, and related compounds. Whether or not these are actually toxic is a matter of controversy. People spraying their lawns with 2,4–D and becoming wet with spray have occasionally developed severe neuritis and even paralysis * * *. It has been shown experimentally to disturb the basic physiological process of respiration in the cell, and to imitate X-rays in damaging the chromosomes (p. 75).
>
> [Fruit flies] developed mutations so damaging as to be fatal on exposure to one of the common herbicides * * * (pp. 190–191).
>
> The full maturing of whatever seeds of malignancy have been sown by these chemicals is yet to come (p. 201).[5]

Various technological assessments were set in motion by the Carson book, or took place concurrently with it. A series of reports were issued by a committee on pest control and wildlife relationships of the National Academy of Sciences-National Research Council.[6] The President's Science Advisory Committee prepared a substantial report on the subject, May 15, 1963.[7] A study conducted by the staff of the House Appropriations Committee was reported April 17, 1965.[8] A lengthy investigation was conducted by the Government Operations Committee of the Senate, culminating in a final report, July 21, 1966. The conclusion of this report offers perhaps the best consensus available on the broad question of whether or not herbicides (and other pesticides) should be used, and if so under what circumstances. It recommended that the present regulatory system should be strengthened to prevent unintentional contamination of the environment, that

---

"The Discovery and Development of 2,4-D." Op. cit., p. 253.

[5] Rachel Carson, Silent Spring. (Greenwich, Conn. Fawcett Publications, Inc., 1962 1966.) 261 p. plus index.

[6] National Academy of Sciences. Committee on Pest Control and Wildlife Relationships. "A Symposium on Pest Control and Wildlife Relationships." By Committee on Pest Control and Wildlife Relationships, Mar. 10, 1961, 25 pp. (Publ. 807); "Pest Control and Wildlife Relationships." Pt. 1: "Evaluation of Pesticide-Wildlife Problems," (1962), 28 pp. (Publ. 920–A); Pt. 2: "Policy and Procedures for Pest Control" (1962), 53 pp. (Publ. 920–B); and Pt. 3: "Research Needs" (1963), 28 pp. (Publ. 920–C). (Washington, D.C., National Academy of Sciences.)

[7] U.S. President's Science Advisory Committee. "Use of Pesticides." The White House, May 15, 1963.

[8] "Effects, Uses, Control, and Research of Agricultural Pe[illegible]des." (A report by surveys and investigations staff.) April 10, 1965. Reproduced in [illegible] Congress, House, Committee on Appropriations, Department of Agriculture Appropriations for 1966. Hearings before a subcommittee of the * * * pt. 1, 89th Cong., 1st sess. (Washington, U.S. Government Printing Office, 1966).

Federal programs of pest control should be coordinated more closely, that health programs relevant to pesticides should be expanded, and that scientific research into the effects of pesticides should be stepped up to provide a more adequate basis for future national policy.[9]

As a result, then, of the apprehensions raised by the Carson book, the need was recognized for more closely controlled use of herbicides, and for more penetrating research into the ecological consequences of their use. At the same time, it became more fully appreciated that the benefits conferred by this use, and the extent of reliance on it for agriculture in a technologically oriented society, could not easily be foregone. Use would continue, but under measured control that would be further refined as knowledge of adverse effects became more precise.

It was during this same period of technological assessment of the domestic use of pesticides generally, that the military use of herbicides began and expanded in Vietnam. This was perhaps not the first time that defoliant chemicals were used in counter-guerrilla warfare.[10] However, their use in Vietnam certainly appears to have been unprecedented in terms of its extensiveness, scope, and systematic nature of application for military objectives.

As the military use of defoliants in Vietnam intensified, various questions were raised by groups and individuals in the United States concerning the morality, the legality, and the possibly adverse long-range consequences, of the program. The rest of this study describes, in sequence, (*a*) the nature of the program in question, (*b*) the evolution of dissent in the United States, (*c*) the exchanges of views by the American Association for the Advancement of Science within its own governing body and with the Department of Defense, (*d*) the efforts of the Department of Defense to perform its own assessment of the technology, (*e*) the subsequent efforts of scientists to perfect their assessment, and (*f*) the present status of the defoliation assessment. The study concludes with a statement summarizing the observations to be drawn from this case as an example of technological assessment motivated by a large professional society, relative to national science policy.

[9] U.S. Congress. Senate. Committee on Government Operations. "Interagency Environment Hazards Coordination, Pesticides and Public Policy." Report of the . . . Made by its Subcommittee on Reorganization and International Organizations (Pursuant to S. Res. 27, 88th Cong., as amended; extended by S. Res. 288, 88th Cong.) S. Rept. No. 1379. 89th Cong., 2d sess., July 21, 1966. (Washington, U.S. Government Printing Office, 1966).

[10] According to Richard L. Clutterbuck, "Helicopters, Pioneers, and the De Havilland Beavers were used [in the British campaign in Malaya] for spraying weed-killer onto enemy cultivations." However, "defoliation to deny the enemy cover was not done in Malaya by air spraying." This strategy was not abstained from as a matter of policy, but on the basis of cost/effectiveness: "The only areas where this could have been both practical and effective were the likely ambush sites along the roads; but that was more effectively done by hand, and there were always more urgent demands for aircraft." The Long, Long War, Cassell (London (1967), p. 160). [Confirmation of this statement in other sources is lacking.]

II. EVOLUTION OF THE MILITARY HERBICIDE PROGRAM

The close of World War II was the signal for a variety of small insurgent uprisings throughout the world, usually characterized by informal or guerrilla forces in challenge of existing governmental authority. These occurred in Greece, Malaya, China, Cuba, Indonesia, the Philippines, the Congo, Cyprus, Algeria, and elsewhere.

In some respects, the British campaign against the guerrillas in Malaya served as a prototype of the later conflict in Vietnam, in that it was to combat a Communist-inspired uprising in a jungle area of Southeast Asia, with an essentially colonial economy, employing weapons of terror against a technologically sophisticated adversary. An important difference was that in Malaya the guerrillas were not in contact with an outside source of logistic support and had no sanctuary. Tactics of counter-guerrilla warfare in Malaya, accordingly, were concentrated on: (*a*) keeping the guerrillas separated from the civilian noncombatant population by fortifying and protecting villages, (*b*) keeping military pressure on guerrillas to wear them down, and (*c*) denying the guerrillas sources of food.[11] Despite a vigorous campaign, however, the Malayan guerrilla war cost the British heavily in wealth, and dragged on for a decade.

Early in his administration, President Kennedy was motivated by the first Cuban crisis and other manifestations of political instability in developing countries to increase the U.S. capability in dealing with "guerrilla forces, insurrections, and subversion." Such a capability would entail a general strengthening of military resources of anthropological, cultural, and other social science data in relevant areas of the world. In his March 28, 1961, message on the Defense budget, the President said that the U.S. interests were threatened by limited guerrilla warfare such as had brought Castro to power in Cuba. To counter the threat of being "nibbled to death," as the President expressed it, the United States needed to strengthen the capability for lower levels of intensity of conflict.

> To meet our own extensive commitments and needed improvements in conventional forces, I recommend the following: A strengthened capacity to meet limited and guerrilla warfare * * * We need a greater ability to deal with guerrilla forces, insurrections, and subversion.[12]

Within limits, the British experience served as a guide to the Government forces in South Vietnam, and to their U.S. military

[11] Several references stress the importance of denying guerrillas sources of food. For example, Lt. Col. Rowland S. N. Mans wrote: "The most successful operations in Malaya were those aimed at denying any form of food supplies to the [guerrillas]." (also) "As their food caches were reduced, the [guerrillas] grew more and more desperate. They took risks that exposed them to Security Force retaliation . . . Lack of food often forced a [guerrilla] to surrender." ("Victory in Malaya," in: Lt. Col. T. N. Greene (ed.), The Guerrilla—And How To Fight Him. Selections from the Marine Corps Gazette. (Frederick A. Praeger, New York, 1962, Praeger Paperbacks), pp. 124–125. Joseph P. Kutger also stresses this theme: "The guerrillas started to feel the pressure of the squeeze. The difficulty of maintaining local supply lines after the relocation of the jungle fringe squatters reduced them to depending upon crops raised in jungle clearings. The last presented the British air arm with suitable targets. The RAF would observe the area and at the propitious moment dampen the spirits of the beleaguered guerrillas by spraying the food plots with poison or setting afire a field about to be harvested." (In: "Irregular Warfare in Transition," Military Affairs. (Vol. XXIV, No. 3 Fall, 1960), p. 121.)

[12] President John F. Kennedy, Special message to the Congress on the defense budget. In Public Papers of the Presidents—John F. Kennedy, 1961. (Washington, U.S. Government Printing Office, 1962), p. 236.

supporters, in the development of strategy and tactics in the Vietnamese war. Among the important differences were the fact that the guerrillas in the latter war were able to concentrate in larger force units, to overrun village redoubts, and then retreat to sanctuaries in the jungle, or in Laos, Cambodia, or north of the demilitarized zone (DMZ). The rice growing areas in the delta country, south and east of Saigon, were abundant sources of food on which the whole country depended; these sources could be denied to the guerrillas only by physically holding the area and taking custody of the crops as they were harvested. On the other hand, the upland and forest areas north and west of the capital city were more sparsely settled. Along supply lines from North Vietnam, the guerrillas developed small plantings in cleared areas to supplement their supplies of food from above the DMZ. These plantings were similar to the slash-and-burn agriculture traditionally practiced by the indigenous Montagnard population in the area.

Tactics of the guerrilla forces in South Vietnam in general involved skillful use of jungle cover and the merging with the local population, as in Malaya. There were roadblocks, with systematic taxing of travelers; retreats to elaborate underground strongholds in the forests; ambushes along roads; sniping at river traffic from the bush; kidnappings, assassinations, and terrorist demonstrations. Logistic transport took place at night, or under the forest cover; use was made as sanctuary of neighboring territory formally denied to defending troops of the Republic of Vietnam.

Before the end of 1961, U.S. assistance to the Diem government in South Vietnam had been limited to military advisers, economic aid, and some logistic support. However, on December 7, 1961, President Diem advised President Kennedy that "the forces of International Communists now arrayed against us are more than we can meet with the resources at hand. We must have further assistance from the United States if we are to win the war now being waged against us." On December 8, the U.S. State Department issued a report describing the pattern of guerrilla activity in South Vietnam, the increased use of terror tactics, the support received from North Vietnam, and the use of Laos as a base and logistic supply route. Shortly afterward, on February 8, 1962, the American Military Assistance Command (Vietnam) was established to supervise American military personnel and coordinate joint planning; by mid-1962, U.S. military forces in the area reached the number of 12,000.

Popular disaffection with the Diem regime, during 1963, culminated in its overthrow by a military coup, November 1; shortly before the assassination in the United States of President Kennedy. At the end of the year, President Johnson after consultation with Defense Secretary McNamara and CIA Director McCone, assured the new government of continued U.S. support. This position was confirmed by joint resolution of Congress, signed August 10, 1964, asserting that the United States was "* * * prepared, as the President determines, to take all necessary steps, including the use of armed force, to assist any member or protocol state of the Southeast Asia Collective Defense Treaty requesting assistance in defense of its freedom." (Public Law 88–408). This resolution became law 8 days after the Tonkin Gulf incident in which the U.S.S. *Maddox* reported being attacked by three North Vietnamese torpedo boats. Bombing strikes against North Vietnamese objectives by U.S. planes began February, and a U.S. Marine battalion landed in Vietnam March 9. Thereafter, the war escalated in intensity, with progressively increased U.S. participation. U.S. forces in Vietnam grew from about 23,000 on January 1, 1965, to about 181,000 at the end of that year; by the end of 1967, they numbered 486,000.

The essential failure of the village redoubt approach to pacification in South Vietnam meant that increased emphasis would need to be placed on other aspects of strategy found effective in the Malayan counterinsurgency campaign (the closest prototype), and that additional new techniques would also be needed. Use of herbicides to remove foliage along thoroughfares as cover for ambushes, which may have been used in a small way in Malaya, become an important part of U.S. practice in Vietnam. The harrying of guerrilla forces, and attempts to encircle guerrilla strongholds, required both aerial reconnaissance and close ground support of military forces; removal of protective cover of foliage was helpful in both cases. Finally, the denial of food, which had definitely played such an important role in the British Malayan campaigns, was extremely difficult in the Mekong Delta region, which was generally a food-surplus area. However, in the areas west and north of Saigon, the population was more sparse and food production much less abundant; in these areas, it seemed feasible to develop the strategy of destroying subsistence crops of the guerrillas, thereby increasing the burden on the logistic supply coming from North Vietnam. Beginning in 1961, herbicides grew to be an important element in Vietnamese counterinsurgency.

Development of Herbicide Warfare in Vietnam

Experiments with defoliant and desiccant chemicals as herbicides had continued at Fort Detrick, after World War II. Some 12,000 chemicals had been tested and the most promising 700 screened in greenhouse and field tests. Some of them had been tried out on tropical vegetation in Puerto Rico. An extensive test, over an area of 4 square miles, had been conducted at Camp Drum, N.Y. Finally, "a variety of chemical agents were shipped to the Vietnamese military authorities, and from July 1961 to April 1962, a preliminary series of defoliation trials were conducted under the guidance of J. W. Brown." The program was then halted, pending an assessment of its military effectiveness. These tests showed that 2,4–D and 2,4,5–T (see table 2) were effective defoliants when applied during a period of active growth; in addition, cacodylic acid sprayed from aircraft showed promise for use against ricefields. While further tests were being conducted by U.S. military forces and under contract, in Thailand, Texas, and Puerto Rico, Vietnamese military forces and U.S. planes sprayed mangrove and nipa palm vegetation along canals and roads east of Saigon, with considerable improvement reported in overhead visibility of the ground.[13]

[13] MRI report, op. cit., pp. 113–115.

chemicals was developed and of limited potential effectiveness. Excerpts:

TABLE 2.—COMPOSITION AND CHARACTERISTICS OF MILITARY HERBICIDES

Agent	Composition	Pounds per gallon AE	Purpose
Orange	n-Butyl ester 2,4-D, 50 percent (weight)	4.2	General defoliation; forest, brush, broad-leafed crops.
	n-Butyl ester 2,4,5-T, 50 percent (weight)	3.7	
Total		8.9	
Purple	n-Butyl ester 2,4-D 50 percent (weight)	4.2	General defoliation; interim agent used interchangeably with orange.
	n-Butyl ester 2,4,5-T, 30 percent (weight)	2.2	
	Isobutyl ester 2,4,5-T, 20 percent (weight)	1.5	
Total		8.9	
White	Tri-isopropanolamine salt 2,4-D	2.0	Forest defoliation; long-term jungle control, brush suppression.
(Tordon 101)	Tri-isopropanolamine salt picloram	.54	
Total		2.54	
Blue	Sodium cacodylate, 27.7 percent		Rapid defoliation (short duration); grassy plant control, rice destruction.
(Phytar 560-G)	Free cacodylic acid, 4.8 percent		
	Water; sodium chloride, bal	3.1	

Source: Midwest Research Institute. "Assessment of Ecological Effects of Extensive or Repeated Use of Herbicides." S. W. B. House et al. Final report, Aug. 15-Dec. 1, 1967. (Hereinafter called "MRI Report".) Sponsored by Advanced Research Projects Agency of the Department of Defense, ARPA Order No. 1085. MRI Project No. 3103-B (Midwest Research Institute, 1967), p. 119.

There is no question but what you can have an effective defoliate. The problem is finding one that is fast enough acting to make it militarily worthwhile.

(Question: [Its use in guerrilla warfare] would not appear to have too great promise or be of too great importance . . .; is that correct?) (Answer: Yes sir; however there are methods of doing this with chemical compounds. And on an experimental basis, we have demonstrated that wooded areas can be stripped of foliage. This work was done as part of our anticrop program.)

* * * The quantity of material to cover an area—well, you can see that they are really small—but when it comes to a number of square miles, the number of square miles that can logistically be covered here, as far as our research work has uncovered, are very few.

Mr. Flood. As a strategic weapon, this has no value?

General Stubbs. No, sir.

Mr. Flood. But, I could particularly use that to advantage in jungle warfare, could I not?

General Stubbs. When it comes to a very limited operations, sir, we have the chemical today that can do that kind of work.

(Question: How long does it take after it is applied to have effect?) (Answer: Unfortunately, it takes too long. This requires some 2 or 3 days.) [15]

Not long after the above exchange took place, preliminary tests were underway in Vietnam. According to one account—

America's defoliation effort in Vietnam began modestly in late 1961. Six C-123 transport planes, traditionally used for carrying soldiers, flew into South Vietnam from Clark Field in the Philippines and were outfitted with special tanks carrying 10,000 pounds of defoliant, enough to cover 300 acres.

The planes flew 60 flights in 1961 and 107 in 1962 as experiments continued. A total of 17,000 acres were sprayed in 1962.[16]

[15] U.S. Congress. House. Committee on Appropriations for 1962. Hearings before the Subcommittee of the . . . Part 4, Research, Development, Test, and Evaluation, 87th Cong. 1st sess. (Washington, U.S. Government Printing Office, 1961), p. 231.

[16] Arturo F. Gonzalez, Jr. "Defoliation—A Controversial M. S. Mission in Vietnam." Data (Vol. 13, Oct. 1968), p. 13. According to records of the Department of the Air Force, no operational spraying was done in 1961 although some test activities were conducted along canals and roads near Saigon. Operational spraying of 5681 acres was carried out in 1962.

bell, stated that among the new techniques employed against the Vietcong was defoliation from the air— "* * * a chemical means of stripping leaves from the foliage that hides Vietcong movements in thickly wooded areas." The report continued: "Known Vietcong bases will be surrounded by bare stretches where the guerrillas will find it difficult to move undetected from their hideouts, which are often underground." [16]

Further explanation of the program appeared in a story datelined January 11, 1962. It indicated that the implementation of defoliation efforts had been delayed pending resolution of "the question of how to publicize this form of chemical warfare * * *."

The spraying now is expected to begin soon, following a formal announcement approved by high officials of both countries. The announcement declares that the chemical operation is intended to "improve the country's economy by permitting freer communication as well as to facilitate the Vietnamese Army's task of keeping these avenues free of Vietcong harassments." [17]

A week later, it was announced by "a high South Vietnamese official" that the program had begun. A 70-mile road from Saigon to the sea had been sprayed "to remove foliage hiding Communist guerrillas" and "defoliant chemicals would also be sprayed on Vietcong plantations of manioc and sweet potatoes in the highlands." The account said that "The exact locations of these plantations have already been plotted by aerial surveys" and tests had been made that showed that "* * * Manoic and sweet potatoes die 4 days after having been sprayed." These were the two most important food staples for the Communist bands in the mountains.[18] However, the decision appears to have been reversed at once. A story datelined January 24, from Saigon, under the byline of Homer Bigart, reported that "The United States has shied away from plans to starve out Communist guerrillas by spraying chemicals on rebel-controlled manioc and ricefields."

The reluctance to join the crop-killing program urged by the South Vietnamese is believed based on American sensitivity to the possibility that accusations would be made that Americans took part in chemical warfare."

A story appearing in the Bankok World, February 24, 1962, attributed to a "spokesman" for the "U.S. Defense Department" stated that: "Commercial weed killer has been sent to South Vietnam in an amount adequate to accomplish the purpose of clearing jungle growth along highways and trails." The "spokesman" was further quoted as saying, in answer to a question: "No, the chemical has not been used for crop destruction."

Apparently, after these first experiments with herbicides, there was a lull in the program, while military assessment was made of their effectiveness. One indication that the experiment had not been an

[16] New York Times. (Jan. 1, 1962), p. 1.

[17] New York Times (Jan. 12, 1962), p. 3. (The Department of Defense takes issue with the New York Times interpretation that spraying programs were delayed by considerations of public relations.)

[18] New York Times. (Jan. 19, 1962), p. 4.

[19] New York Times. (Jan. 20, 1962), p. 1.

unqualified success was a story appearing in the Washington Post, March 25, 196[redacted] bore the headline "U.S. Defoliation Project in Vietnam Calle[redacted]op." [20] Reference illustrative of the military assessment of herbici[redacted] effectiveness is presented in a study by the Agricultural Research Service of the U.S. Department of Agriculture, under contract to Advanced Research Projects Agency of the Department of Defense, February 1968. This study reported:

> Some forested areas in Vietnam were sprayed with herbicides in the early 1960's in an effort to reduce the amount of obscuration by vegetation. The results were particularly good on mangrove in coastal areas and along canals. Results on evergreen rain forests and upland semideciduous forests left much to be desired. Consequently, a team of military and civilian experts reviewed the operational spray program and made recommendations for improvement. Since there was a dearth of information available about the response of tropical woody plants to herbicides, a research program was recommended that would answer some of the critical problems involving the defoliation of tropical forests.[21]

During March 1962, Roger Hilsman, a senior adviser in the State Department, visited Vietnam and on his return prepared a number of memorandums on current issues, one of which was the use of defoliants—a device that, he said, "had political disadvantages" and was of doubtful benefit. Excerpts from a later statement by Hilsman on this period are as follows:

> Defoliants * * * were new. They were chemical weed killers, which had been highly developed in the United States and were widely used, for example, to kill vegetation along the rights of way of power lines. The military headquarters in Saigon thought that these defoliants would be ideal for clearing the underbrush along the sides of roads where the Vietcong laid their ambushes and for destroying crops in areas under Vietcong domination, and General Taylor and the Joint Chiefs of Staff agreed. The State Department view, on the other hand, was that the political repercussions would outweigh any possible gains. Defoliation was just too reminiscent of gas warfare. It would cost us international political support, and the Vietcong would use it to good propaganda advantage as an example of the American making war on the peasants. My own feeling was that at a much, much later stage, when the Vietcong had been isolated from the population and were attempting to grow their own food in the mountains, the advantages might be significant.
>
> [Hilsman questioned the advantage of defoliants either to deny food to guerrillas or to remove cover for ambushes at the time in question.] * * * As for removing the cover for ambushes while in Vietnam I had flown down a stretch of road that had been used for a test and found that the results were not very impressive. * * * Later, the senior Australian military representative in Saigon, Colonel Serong, also pointed out that defoliation actually aided the ambushers—if the vegetation was close to the road those who were ambushed could take cover quickly; when it was removed the guerrillas had a better field of fire. But the National Security Council spent tense sessions debating the matter.[22]

Military assessment of defoliants appears to have involved such questions as the feasibility of developing techniques by which large, slow-moving and low-flying aircraft could traverse enemy-occupied jungle terrain without being shot down; the selection of the appropriate chemicals for particular kinds of foliage to be stripped of leaves; the timing of the spray missions in relation to the local rainfall pattern, and local wind conditions, in addition to military tactical requirements; and the survey of the area to be sprayed to determine the risk and extent of inadvertent damage to crops and rubber plantations. This learning process coincided with internal instabilities within the Saigon government, and the gradual enlargement of U.S. military personnel serving as advisers to the field forces of the Government. Meanwhile, separate experiments in U.S. territory, and in Thailand, helped toward perfecting the techniques of application. In particular, the military authorities in the United States were concerned over the various timelags in defoliation evidenced by the different species of plants to which the sprays were applied.

Evaluation of the proposed military uses of defoliant chemicals by the Department of State, judging by the Hilsman discussion, involved the impact of world opinion on U.S. foreign relations. The various work orders by the Advanced Research Projects Agency (ARPA) of the Department of Defense to the Department of Agriculture had to do initially with the military effectiveness of the chemicals. Later on, questions were explored as to residues in plants and in the soil (March 5, 1965); however, in these initial stages no significant emphasis appears to have been placed on the need for research concerning the long-range effects of herbicides on the ecology.

The Department of Agriculture studies for ARPA included (*a*) vegetation of Southeast Asia: Studies of forest types, December 1965; (*b*) forests of Southeast Asia, Puerto Rico, and Texas, published September 1967; and (*c*) response of tropical and subtropical woody plants to chemical treatments, February 1968.

To prepare the first report, Fred H. Tschirley, Crops Research Division, Agricultural Research Service, USDA, visited Thailand during December 1963 to January 1964, and December 1964 to February 1965. In Thailand he was assisted by Thai forestry experts, and particularly Mr. Tem Smitinand, taxonomist in the Royal Forest Department of Thailand. The purpose of this first reconnaissance was to identify the characteristic types of foliage growing in wooded areas of Southeast Asia.

The second report from USDA to ARPA was a comparative study of forests in Southeast Asia in comparison with forests in Puerto Rico and Texas. The foreword to this study states:

> * * * Information on the floristic composition and structure of a particular forest type, occurring under tropical, subtropical, or temperate conditions, is essential for comparative purpose, and is of value to the ecologist, forester, geographer and others. In brief, vegetation is the summation of climate, soil types, and general conditions in a particular environment.
>
> Throughout the report, emphasis is placed on analogous and anomalous features of the forests of Southeast Asia, Puerto Rico, and Texas. This comparison is based principally on investigations conducted by the author [Llewelyn Williams] throughout Thailand at intervals during 1963 to 1965; in Puerto Rico in April 1963 and June 1966; and in eastern Texas in September 1966. Other studies, especially on seedlings appearing in successional growth, were conducted in Puerto Rico by J. A. Duke during 1963 to 1965.

The third report, compiled by Tschirley, described the results of experiments with herbicides in Puerto Rico and Texas, and interpreted the effects in relation to military objectives in Vietnam.

An indication of the development of the scientific aspects of the program is provided by the summary of successive work orders and

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[20] P. A-12.

[21] U.S. Department of Agriculture, Agricultural Research Service, "Research Report . . . Response of Tropical and Subtropical Woody Plants to Chemical Treatments." Compiled by Fred H. Tschirley. Under ARPA Order No. 424, Advanced Research Projects Agency, U.S. Department of Defense. CR-13-67. (February 1968), pp. 3-4.

[22] Roger Hilsman, To Move a Nation. (Garden City, New York, Doubleday, Inc., 1967), pp. 442-3.

ARPA Order [illegible] [issued Jan. 30, 1963] was established for a 2-year period. The objectives of the work in College Station, Tex., were to: "Discover and evaluate new herbicides and principles for killing trees, brush and other vegetation; develop methods of evaluating herbicides on different species of woody vegetation; develop methods and principles for improved application techniques; and determine effects of promising herbicides." The objectives of the research in Puerto Rico were to: "Conduct advanced evaluation of promising herbicides for killing tropical and subtropical vegetation; and determine optimum times and rates of application, distribution patterns, formulations and mixtures for most effective use of herbicides." The objectives of the taxonomic investigation were to: "Obtain sufficient botanical information so that correlations can be made between vegetation indigenous to CONUS and Puerto Rico, and Southeast Asia.

ARPA Order No. 424 was extended for an additional year by amendment No. 2 dated March 5, 1965. Additional objectives of the research were to: (1) Emphasize effects of environment on behavior and effectiveness of herbicides and persistence of control including residues in soils and plants, (2) study secondary succession of vegetation following different herbicidal treatments as related to "visibility," (3) correlate the results of defoliation in Texas and Puerto Rico, (4) investigate methods for improving absorption, translocation, and activity of herbicides and defoliants, and (5) compare the penetration of sprays through a forest canopy that is obtained from a cableway system with that obtained from aircraft.

A second extension was granted by amendment No. 3, dated March 20, 1966. During the final year of the project, increased emphasis was given to the effects of environment on herbicidal effectiveness, the composition and frequency of successional species following herbicidal treatment, the effect of defoliation and subsequent regeneration on the degree of obscuration, and herbicidal residues in both plants and soils.

The interrelation of data from the fields of taxonomy, ecology, weed science, and engineering have been extremely valuable during the course of this project. It is axiomatic that the breadth of a study determines the extent to which data developed from that study can be extrapolated. For example, a great deal of research had been done on the control and defoliation of woody plants in temperate zones. Information was available regarding which herbicides were most effective, what rates should be used, and when treatments should be made. But no one could extrapolate that information to a tropical evergreen forest with any degree of assurance. In like manner, penetration of a spray solution through a forest canopy would be expected to be different for a desert shrub formation, a coniferous forest, a temperate deciduous forest, and a tropical evergreen forest. Once the effective herbicides, the penetration of spray solutions, and the taxonomic affinities of several diverse vegetative types are known, extrapolation of that information to entirely new areas can be made with much more assurance. Thus, the correlated efforts of taxonomists, engineers, and weed scientists in the ARPA project has provided information that can be applied with reasonable assurance on a worldwide basis, rather than being restricted to the area of investigation."[24]

By July 1963, the main emphasis in military research in herbicides was on shortening the reaction time of plants treated. However, the technology was so new—for military purposes—that precise performance specifications had not been developed. As one civilian scientist expressed it:

> It goes without saying that the materials must be applicable by ground and air spray, that they must be logistically feasible, and that they must be non-

[24] U.S. Department of Agriculture, Agricultural Research Service, Research Report . . . Response of Tropical and Subtropical Woody Plants to Chemical Treatments. Compiled by Fred H. Tschirley, Crops Research Division. Based on Research Conducted by L. F. Bouse, et al. Under ARPA Order No. 424, Advanced Research Projects Agency, U.S. Department of Defense, CR-13-67, February 1968 (U.S. Department of Agriculture, 1968), pp. 4-5.

respect to the usual military-industrial collaboration * * *. In this [illegible]am we do not have rigidly specified characteristics. I have stated some of the broad requirements that a successful defoliating chemical should have but within this general framework we will accept and use materials that will do a job for us. In a few years it may be that we will come up with more definite specifications* * *."[25]

During the first 5 years of defoliant use, the rate of increase was slow. In 1961, only 60 missions were flown; 107 occurred in 1962. However, by the latter part of 1965 the rate of use began to increase sharply. (See table 3.)

TABLE 3.—ESTIMATED AREA HERBICIDALLY TREATED IN SOUTH VIETNAM, THROUGH 1968 [1]

[Figures in square miles]

Year	Defoliation	Crop attack	Total area sprayed
1962	8	1	9
1963	39	(2)	39
1964	130	16	146
1965	240	103	343
1966	1,169	158	1,313
1967	2,320	348	2,668
1968	1,980	100	2,080
Total [3]	5,877	726	6,603

[1] Source: Letter to Representative McCarthy from Legislative Liaison, Department of the Air Force, May 15, 1969.
[2] Less than 1.
[3] These figures do not represent total acreage sprayed because multiple spraying occurred on some acreages. They are figures calculated from missions flown, tank capacity, and rate of application. The area of land actually receiving herbicide is estimated at about 60 percent of the indicated total. At 640 acres to the square mile, the total area receiving spray is about 2,540,000 acres and the total amount of treatment applied is about 4,226,000 acres.

Full-Scale Military Use of Herbicides, 1966–69

By 1967, herbicide usage in Vietnam began to level off. However, military procurement of defoliant chemicals continued to climb, to build a stockpile of reserves for the future.[26] According to an official statement about the program, released in Saigon:

> By December, 1962, Ranch Hand [code name of the aerial defoliation program unit] had completed two new projects. These were the defoliation of canals and rivers in the south and a pass south of Qui Nhon.
>
> In 1963 lines of communications targets included a powerline from Dalat to Saigon, the railroad from Saigon to Phan Thiet, and other highways and canals. Because ground fire and hits to aircraft were increasing, the Ranch Hand unit experimented with spraying at night with lighting provided by flare ships and by moonlight alone. These operations were discontinued mainly because of the small chance of rescue in the dark.
>
> Defoliation operations increased in 1964, and hits on aircraft became more frequent until on April 30, one aircraft was hit 14 times, and the copilot was

[25] U.S. Army, Biological Laboratories, Crops Division, Proceedings of the First Defoliation Conference, July 29-30, 1963, Biological Laboratories, Fort Detrick, Maryland. Compiled by Vesta Z. Mattle. (January 1964, AD #427874), pp. 13, 16.

[26] Beginning April 1, 1967, military rated orders preempted production of 2,4,5-T for use with 2,4-D to produce "Orange" herbicide, the most extensively used chemical defoliant in Vietnam. As production increased and military requirements slackened, the controls were lifted during April-May, 1968. They were then restored, and all June production went to military purchasers. Thereafter, allocation was partial, and by mid-December, 1968, the controls were terminated. Since then, the military services have purchased no herbicide at all. Actual expenditures for military herbicide rose from $12.5 million in the fiscal year 1966 to $45.2 million in F.Y. 67, and remained about at that level for another year.

wounded. At this time operations were discontinued for military reassessment, they were resumed only with increased sorties programed.

A gradual increase in sorties continued during 1965, and in mid-November the Ranch Hand mission was almost doubled as three additional aircraft and crews arrived from the United States.[26]

In the spring of 1965 the first systematic program of aerial spraying to destroy food crops was begun in Vietnam. A story datelined December 20 from Saigon, under the byline of Charles Mohr, in the New York Times described this program as having begun "last spring." It was "a politically delicate subject." According to the story, "officials say that no herbicide [i.e., crop destroying] missions have been flown or will be flown in heavily populated areas" (such as the Mekong Delta). The missions were "aimed only at relatively small areas of major military importance where the guerrillas grow their own food or where the population is willingly committed to their cause."[27] By early March 1966, crop destruction had become an important phase of counterguerrilla activity. A statement was made public by the Department of State, March, 9, reporting that some 20,000 acres of crops had been destroyed to deny food to guerrillas. The areas involved were described as remote and thinly populated, and "known from intelligence sources to be occupied by Vietcong military units." The statement also described precautions being taken in the crop-defoliation program to avoid adverse effects on noncombatants:

The herbicides used are nontoxic and not dangerous to man or animal life. Food land is not affected for further use.

The Vietcong and any innocent persons in the area are warned of the planned action. They are asked to leave the area. They are promised food and good treatment when they move out. Those who have moved from Vietcong territory for this reason have been fed and cared for.[28]

By September 1966, the defoliation spraying program by aircraft against forest cover had been extended near the DMZ.[29] By the end of that month, the possibility of defoliating jungle growth within the DMZ itself was reported to be under consideration by the Joint Chiefs of Staff. It was also reported that Gen. William C. Westmoreland, Commander of U.S. Forces in South Vietnam, had asked for Presidential approval to use herbicides to defoliate 50 square miles of the jungle-covered mountains of the DMZ.[30]

By early 1968, the program had been well established for both removal of jungle cover and crop destruction. The Department of Defense released statistics covering the year 1962–67.[31] At about this same time, it was announced that the Air Force was "preparing to dump 19 million gallons of vegetation and crop-killing poison over South Vietnam in the year beginning in July" of 1968–69. The chemicals required would cost $70.8 million. The report concluded: "Flights of Air Force C–123's equipped with 1,000-gallon chemical-dispensing tanks began in 1962 with a modest 107 missions. Chemical operations have continued to escalate, however, and by 1966, U.S. planes were flying more than 3,000 spray sorties a year."[32]

In actuality, the military use of herbicides in Vietnam reached its peak in the fiscal year 1967, and declined somewhat in each of the following 2 years. Whether or not in response to the cautions expressed by Dr. Tschirley of the U.S. Department of Agriculture (see pp. 50–51) and Dr. Pfeiffer of the University of Montana (see p. 60) there was evidence of an increased military restraint in herbicide usage. The complex mechanism of defoliation target selection that had evolved to apply the expanding criteria of suitability (see p. 18 sq.) provided opportunity to bring these cautions to bear on military herbicide operations. Moreover, with increasing experience, the military services themselves had become better able to judge both the values and the limitations of herbicide application. By May 1969, the Department of the Army was preparing to issue a new manual of instruction on herbicides for troop use. (See app. A for text of the draft.) In addition, the Department of the Air Force was soliciting a contractor to perform work looking toward the "ultimate goal" of a "handbook for Air Force base civil engineers with worldwide recommendations for effecting vegetation control."[33]

Decisionmaking Arrangements for Military Uses of Herbicides in Vietnam

The complex political situation in Vietnam has resulted in numerous difficulties in U.S. support of the Republic of Vietnam (RVN). Military and political decisions are complicated by three sets of circumstances: (1) by the informal nature of the undeclared war, with its mixture of regular and irregular troops confronting RVN and supporting U.S. forces; (2) by the mixture of economic motives in which the progress of the RVN toward economic and political sovereignty by replacing a colonial economy with a self-controlled economy has been retarded by widespread hostilities and local guerrilla demonstrations; and (3) by the mixture of objectives of U.S. personnel in the area, with economic assistance under the U.S. AID program requiring coordination with U.S. military assistance for the RVN against guerrilla and North Vietnamese forces.

The use of herbicides in support of military objectives is similarly complicated by these sets of circumstances. Although extensive U.S. military forces have been brought into the territory over which RVN asserts sovereignty, the role of these forces is as invited assistance in support of a friendly nation. Accordingly, the use of herbicides, a novel form of military technology, has required two sets of formal military approval. In addition, since U.S. objectives in the area encompass not only military but also economic and sociopolitical goals, the actual field plans for usage of herbicides for military purposes has required review for military, economic, and sociopolitical effects.

[26] As reported in: Takashi Oka, "Tight Controls Pinpoint Defoliation," Christian Science Monitor, (Mar. 28, 1966), p. 4.
[27] Charles Mohr, "U.S. Spray Planes Destroy Rice in Vietcong Territory," New York Times, (Dec. 21, 1965), p. 1.
[28] "U.S. Tells of Crop Destruction in South Vietnam," New York Times, (March 10, 1966), p. 9.
[29] "U.S. In Defoliation Near Buffer Zone," (Story datelined Saigon, September 23.) New York Times, (Sept. 24, 1966), p. 2.
[30] "Front-Line Units Back Defoliation," New York Times (Story Datelined Danang, Sept. 28) New York Times, (Oct. 2, 1966), p. 7.
[31] "U.S. To Expand Defoliation in South Vietnam," Washington Post, (May 13, 1968), p. A–17.
[32] "U.S. To Increase War Use of Crop-Killing Chemically," Washington Post (May 10, 1968), p 6.
[33] "Research and Development Sources Sought," Commerce Business Daily, (Mar. 28, 1969), p. 6.

Insofar as U.S. military forces are concerned, the All-Service Manual of Armed [redacted] Doctrine for Chemical and Biological Weapons Employment and Defense[34] specifies that "The President of the United States makes the decision to employ CB weapons." Also, "The decision for U.S. forces to use chemical and biological weapons rests with the President of the United States." It adds that "commanders are currently authorized to use * * * defoliants."[35] Defoliant is defined in this manual as "a chemical used to remove prematurely the leaves from plants."

Although the President of the United States received, and acceded to, a request from the RVN for the use of herbicides, the policy was established at the outset that proposals for defoliation actions would be initiated by the Vietnamese people, locally, and would be reviewed by both military and economic groups, and by both United States and Republic of Vietnam authorities. A statement issued by the Department of Defense, late in 1967, describes in general terms the modus operandi involved in this program, as follows:

It is the policy of the Government of Vietnam to take every possible step to raise the production of food for its people. It is the policy of the United States to assist the Vietnamese in this effort. Many steps have been taken in the past in this direction—through the import of fertilizer, the introduction of new strains of livestock, improved growing techniques, and other methods. As a result of the recent Honolulu conference and the visit to Vietnam of Secretary Freeman and a team of agricultural experts, new and more intensive efforts are being undertaken in this direction.

One question has been asked how can we and the Vietnamese try to increase food production, on the one hand, while defoliating trees and destroying crops, on the other. First, these two matters should be separated.

Defoliation has been used to deprive Communist guerrillas where possible of cover and concealment. It is used along roads, railroads, and canals where the Vietcong have regularly taken advantage of thick foliage to set up ambushes against both military and civilian traffic. It is used against remote Vietcong base areas where the Communists have used thick natural cover to conceal their heavily fortified training and regroupment centers. It is used against known trail routes which the Communists have used as supply channels for men and weapons in South Vietnam.

In some cases, herbicides have been used to destroy crops in remote areas being occupied by the Vietcong. The areas affected are known to be used to produce food for Vietcong military units in the area. In war, food is as essential to the effectiveness of a military unit as its weapons and ammunition.

Several things should be noted in this connection. The areas affected by this limited crop destruction program are remote and thinly populated. They are known from intelligence sources to be occupied by Vietcong military units. The herbicides used are nontoxic and not dangerous to man or animal life. The land is not affected in terms of future use. The Vietcong and any innocent persons in the area are warned of planned action. They are asked to leave the area. They are promised food and good treatment when they move out. Those who have moved from Vietcong territory for this reason have been fed and cared for.

A second point—all defoliation and crop destruction actions are initiated by the Vietnamese themselves, usually a district or province chief who has located an area of known Vietcong occupation.

The aircraft and technical capability for this program are largely American simply because the Vietnamese do not yet have the personnel and equipment necessary. But there is Vietnamese participation at every stage and the initiative for all such programs is entirely Vietnamese.[36]

[34] FM 101-10/NPW 36(c)/AFM355-2/LFMO 3, Departments of the Army, the Navy, and the Air Force, April, 1964, p. 3.
[35] Ibid., p. 4.
[36] Department of Defense, "The Use of Defoliants in Vietnam." (One-page, mimeographed fact sheet. No date.)

A news account of this program of target selection and approval, early in 1966, described it as follows:

Setting up targets is a ticklish diplomatic business. Nominations are made by either United States or Vietnamese army commanders, but if an American officer wants a target sprayed, he has to pass the recommendation on to a Vietnamese officer, who goes over the target with the province chief. Then the recommendation goes to the Vietnamese Army's general staff in Saigon and, if approved, the request is sent on to the intelligence section of the U.S. Military Assistance Command—Vietnam in Saigon.[37]

In practice, requests for approval of herbicide targets proceed up two parallel chains of command. Specific approval or disapproval actions are required at each level of both chains. One is the Army of RVN chain which requires approval of the district and province chief, and three other levels, before being submitted to the U.S. Military Assistance Command—Vietnam (MAC–V). The other is the U.S. chain, which runs through district adviser, sector adviser, divisional senior adviser, and corps senior adviser, before going to MAC–V. Approval by these officials carries with it the assurance of approval by local civilian U.S. technical authorities (AID, etc.) at these levels. At headquarters, MAC–V, the target requests, countersigned up both chains, are coordinated with Joint Staff intelligence, Joint Staff operations, the Chief of Staff, the Embassy, U.S. AID, and two civil affairs groups—the civil operations revolutionary development support (CORDS) and the psychological warfare directorate (MAC–PD). Coordination is managed by MAC–V office 203. Only when approval has been completed may the proposed target be scheduled.[38]

An indication of the scope of information needed to accompany a target request is the following "Checklist for Defoliation Requests" prepared for use in this process:

CHECKLIST FOR DEFOLIATION REQUESTS*

1. Overlays or annotated photographs depicting the exact area.
2. Target list:
   - (a) Area—Province and district.
   - (b) UTM Coordinates.
   - (c) Length and width.
   - (d) Number of hectares.
   - (e) Type of vegetation.
3. Justification:
   - (a) Objectives and military worth.
   - (b) Summary of incidents.
4. Psywar annex (prepared by sector):
   - (a) Leaflets.
   - (b) Loudspeaker texts.
5. Civil affairs annex (prepared by sector):
   - (a) No crops within one km.
   - (b) Contingency plan to provide food or money to families whose crops are accidentally damaged by the defoliation operation.
6. Certification by province chief:
   - (a) Province chief approval.
   - (b) Indemnification will be made [by RVN] for accidental damage to crops.

A major consideration in decisions to approve a proposed target for herbicide application is whether it accomplishes a military objective

[37] W. Pruden, "Defoliating the Jungles in Vietnam," National Observer, vol. 5, no. 9, 1-1-, February 28, 1966. Quoted in MRI Report, Op. cit., p. 126.
[38] Information provided by Dr. Minarik, May 5, 1969.

*Source: Mimeograph sheet supplied by Dr. Minarik.

without doing appreciable injury on the side to resources in friendly hands. From time to time, the U.S. civilian authorities at the Saigon Embassy have been quoted as being critical of the herbicide program for its adverse effects on the economy of the country. There appears to be no question but that the program has injured the economy—through inadvertent damage to rubber plantations, injury to timber crops, and drift onto food crops, for example. Inadvertent damage is apparently inescapable. However, it is reported that complaints of inadvertent damage, collected and reported by U.S. AID, which earlier were numbering some 30 a month, had been reduced to 3 a month by early 1969.[39]

Constraints on the program are imposed by physical circumstances. Defoliation is most effective during the growing season, and is much less effective and slower at other times. The type of foliage to be attacked must be related to the type of chemical to be employed, and to the quantity required. Aircraft spraying is performed, usually with ORANGE (2,4-D combined with 2,4,5-T), usually at the rate of 3 gallons (32.25 pounds) per acre. It is delivered by aircraft flying at an altitude of 150 feet, at an airspeed of 130 knots.[40] To avoid drift it calls for spraying during early morning hours "while inversion temperature gradient prevails and the wind speed is still low (does not exceed 8 knots)."[41]

As to the rate of application of herbicide, Dr. Minarik has said:

> This potent herbicidal mixture [i.e., ORANGE] is being applied without precision; but this is necessary to reduce the number of sorties required to cover an area of a given size or to state it conversely, to maximize the area covered per mission.
>
> Three gallons per acre deposit is employed. We would prefer to use less if we could get uniform deposition, but in these dense jungle areas where there may be 300 tons of vegetation per acre, this is the minimal effective volume. The 3 gallons contains 24 pounds of herbicide on an acid equivalent basis. This high dosage rate is also a requirement since much of the vegetation consists of trees 100 to 150 feet tall.[42]

Military assessment of the program has been sustained throughout, and has received the participation of both scientific staff people in the Pentagon, and military and civilian personnel in Saigon. An account of the course of this assessment was recently reported in the following terms:

> Prior to operations in Vietnam the DOD sponsored research by the Department of Agriculture in Southeast Asia, Puerto Rico, and Texas, to ascertain the effects of massive herbicide use on analog vegetated areas. This research resulted in two rather lengthy reports [which were]:
>
> "Forests or Southeast Asia, Puerto Rico, and Texas." USDA Report CR-12-67, September 1967, AD-82-1070.
>
> "Research Report—Response of Tropical and Sub-Tropical Woody Plants to Chemical Treatments." USDA Report CR-13-67, February 1968, AD-675850.

[39] As reported by Dr. Minarik. For comparison, a one-year record of herbicide injuries to crops in North Carolina, in the year 1965, showed 259 cases of drift damage to 1,194 acres, causing losses of $93,259. (Source: Proceedings 1967 Western Weed Control Conference, pp. 21, pp. 20–22, March 15, 16, 17, Phoenix, Ariz. A. D. Worsham: Emphasizing Safe Use of Herbicides.)

[40] C. E. Minarik, "The Use of Herbicides in Vietnam." Paper delivered before Northeastern Weed Control Conference, New York City, Jan. 1968.

[41] Draft manual on use of chemical agents, chapter on "Antiplant Agent Operations, Section I, Technical Aspects" MS supplied by Department of Defense. No date.

[42] Minarik. Op. cit., p. 4.

Based on these studies, and upon the knowledge that the use of hundreds of millions of pounds of herbicide in the United States over 20 years had no startling adverse effects, the United States proceeded with the [illegible] program for the purpose of increasing visibility in heavily forested areas to reduce ambush along roads and canals and to increase ground and aerial surveillance of Vietcong hideouts.

The use is restricted to South Vietnam, always with the approval and usually at the request of South Vietnamese authorities. Requests for approval are considered at several levels of military and civilian authority, both Vietnamese and United States. In all cases approval of the province chief, and the central government is required.

Realizing that the area of long-term ecological effects of massive use of herbicides was not very well known, the DOD sponsored a study in 1967 to collect the available information. This study is * * * as follows:

> "Assessment of Ecological Effects of Extensive or Repeated Use of Herbicides", Midwest Research Institute, Kansas City, Mo., December 1967, AD-824314.

The study dealt largely with the effects of herbicides in the United States, where massive, repeated use has been carried out for the purposes of crop, range, and pasture management, right-of-way maintenance, and control of weeds in waterways and miscellaneous areas. * * *

We requested the National Academy of Sciences to review this report for accuracy and completeness, which they did. The report and the review were then sent to the American Association for the Advancement of Sciences for consideration by the Board of Directors. * * *

Subsequent to this effort, Ambassador Bunker of the U.S. mission in Saigon convened a group to consider all aspects of the herbicide operation. * * * The technical study contributory to [the release of data by the mission] was performed by Dr. Fred Tschirley of USDA, who published his findings in Science, volume 163, February 21, 1969. He has recommended that ecologic research be conducted in Vietnam after cessation of hostilities, that continuing assessment be made in Vietnam, and that defoliation be conducted in strips or checkerboard patterns to leave undefoliated areas for seed source and wildlife habitat. His recommendations were endorsed in principle by Ambassador Bunker. * * *[43]

Indications are available that the screening process for approval of herbicide targets is more than pro forma. There are many assertions that no aerial herbicide spraying has been conducted in the large delta area south and east of Saigon, and no evidence has been found to the contrary. Also, according to Dr. Minarik, a number of province chiefs have given a general disapproval to spraying within their jurisdictions. Crop spraying has been sharply reduced in 1968–69. Reports of complaints or damage claims are also at a lower level than formerly. These circumstances seem to suggest that military use of herbicides has become increasingly selective and that controls are in effect, subject to many different sets of criteria at different levels of review.

The extent to which military control in the field of the use of herbicides is responsive to policy direction from the Office of the Secretary of Defense, and the extent to which this policy direction has been responsive to technical studies undertaken under the stimulus of criticisms of the program by outside scientists, are matters of pure speculation. However, it is evident that the program has received a great deal of official review at many levels, and also that it has been the subject of a wide range of expressions of concern by many scientists. The record of these expressions of concern is surveyed in the two chapters to follow.

[43] Letter from R. L. Harris, Deputy Assistant Director (Chemical Technology), ODDR&E to Professor Charles Townes, Department of Physics, University of California at Berkeley, Apr. 23, 1969.

III. CRITICISM OF HERBICIDE WARFARE

Various gr[redacted] were found for expressions of disapproval of the use of defolia[redacted]micals in Vietnam, when directed against guerrilla crops or jungle cover. The earliest criticisms questioned the military effectiveness of the technology, and the risk of inadvertent injury to Vietnamese crops and plantations. For example:

> * * * Our chemical warfare people have been very unhappy for the last 4 or 5 years about the whole operation. * * * Defoliation is no new gimmick with the Army Chemical Corps. They have come here and shown us pictures and told us that in some areas it was not effective. It was not tactically successful.[41]

An early protest by scientists against military uses of herbicides was contained as an addendum to a statement on biological and chemical weapons, adopted by the Federation of American Scientists, at a spring 1964 meeting of the FAS Council. After urging "no first use" of chemical and biological weapons, and discussing these at some length, the statement concluded:

> Finally, we are concerned with reports of the field use of chemical weapons in Vietnam. Allegations relating to the use of antiCrop agents under American supervision have been officially denied. However, reports that defoliating agents have been used to destroy protective cover have been confirmed by representatives of the Department of Defense. These charges give rise to the broader implication that the United States is using the Vietnamese battlefield as a proving ground for chemical and biological warfare. * * * We are * * * opposed to experimentation on foreign soil, and also feel that such experimentation involving citizens of other countries compounds the moral liability of such actions.[42]

Later, when antiCrop use of defoliants had been adopted as a policy in Vietnam, a protest was addressed specifically against this practice by a group of 29 scientists from the Boston area, under the leadership of John Edsall, professor of biochemistry at Harvard University, in January 1966. However, the remedy sought by the protesters was the complete abolition of the use of defoliants. The group appealed to the President "* * * to proclaim publicly that the use of such chemical weapons by our Armed Forces is forbidden, and to oppose their use by the South Vietnamese or any of our allies." According to the statement—

> Even if it can be shown that the chemicals are not toxic to man, such tactics are barbarous because they are indiscriminate; they represent an attack on the entire population of the region where the crops are destroyed, combatants and noncombatants alike. [Moreover, such attacks would serve as a] precedent for the use of *similar* but even more dangerous chemical agents against our allies and ourselves. Chemical warfare is cheap; small countries can practice it effectively against us and will probably do so if we lead the way. In the long run the use of such weapons by United States is thus a threat, not an asset, to our national security.[43]

During the latter half of 1966, a move was initiated within the membership of the American Association for the Advancement of Science (AAAS) to formulate and adopt a policy concerning military use of herbicides. The lengthy process of assessment by the AAAS is the subject of the following section of this study. The remainder of the present section will give illustrative examples of [redacted] protest movements, during 1967 and after, that lent prominen[redacted]e issue.

A more broadly based protest of scientists against "[redacted]eakening of the worldwide prohibitions and restraints on the use of chemical and biological (CB) weapons" was expressed in a letter to President Johnson, September 19, 1966, by 22 scientists from 12 different educational institutions (seven Nobel laureates). This group related to "CB weapons" the "large-scale use of antiCrop and 'nonlethal' antipersonnel chemical weapons in Vietnam." This activity was seen as a "dangerous precedent" because "no lasting distinction seems feasible between incapacitating and lethal weapons or between chemical and biological warfare." These chemical and biological agents formed a "continuous spectrum" such that "if the restraints on the use of one kind of CB weapon are broken down, the use of others will be encouraged." Accordingly, the group urged the President to—

> "Institute a White House study of overall government policy regarding CB weapons and the possibility of arms control measures * * *."
> "Order an end to the employment of antipersonnel and antiCrop chemical weapons in Vietnam."
> "Reestablish and categorically declare the intention of the United States to refrain from initiating the use of chemical and biological weapons."[44]

Both lists contained the names of four members of the faculty of the Harvard University biological laboratories. These were: John Edsall, Matthew S. Meselson, Keith R. Porter, and George Wald. Edsall and Meselson were credited, late in 1966, with collecting the signatures of more than 5,000 scientists as cosponsors of the second petition to the President.[45] The petition was delivered in person, February 14, 1967, by four of the scientists "who were the moving force behind the petition" to Donald F. Hornig, President's Science Adviser. "The originators sent out 50 to 100 letters and the Federation of American Scientists sent letters asking its 2,500 members to get signatures, the men explained."[46] Among the signatories of the petition were 17 Nobel laureates and 129 members of the National Academy of Sciences. Those presenting the petition were Meselson, Edsall, and Paul Doty of Harvard, and Irwin C. Gunsalus of the University of Illinois.[50]

In midsummer 1967, Edsall again attacked antiCrop chemicals. His views appeared in Scientist and Citizen, a journal published by the committee for environmental information, St. Louis, Mo., in a special issue addressed to the subject of chemical and biological warfare. He asserted that "fateful policy decisions, regarding the development and use of [chemical and biological weapons], now confront us and other peoples throughout the world." The immediacy of such decisions, he went on, "largely arises from the use, by our own Armed Forces in

[redacted]

[41] U.S. Congress. House. Committee on Appropriations. Department of Defense Appropriations for 1966. Hearings before a Subcommittee of the . . . Part 5, Research, Development, Test, and Evaluation. 89th Cong., 1st sess. (Washington, U.S. Government Printing Office, 1965) pp. 368–9.
[42] "FAS Statement on Biological and Chemical Warfare," Bulletin of the Atomic Scientists (October 1964), pp. 46–47.
[43] "Scientists Protest Viet Crop Destruction," Science (Jan. 21, 1966), p. 309.
[44] "Scientists Speak Out On CB Weapons," Bulletin of the Atomic Scientists (November, 1966), p. 39.
[45] "CB: Entering Wedge," The Nation, (Jan. 16, 1967), p. 68.
[46] "5000 Scientists Ask Ban on Gas in Vietnam," Washington Post, (Feb. 15, 1967), p. A–1.
[50] "Chemical and Biological Warfare Petition," Science, (Feb. 17, 1967), p. 813.

Vietnam, of 'antiriot' gases in military operations, and of defoliants and herbicides to destroy crops in areas under control of the Vietcong." [51]

In the same issue of the journal, Jean Mayer, professor of nutrition at Harvard University, attacked the use of herbicides to destroy crops on the ground that the target of this weapon was "the weakest element of the civilian population." He contended that military services, including even Vietnamese guerrillas, had better medical care than civilians, and also "Vietcong soldiers may * * * be expected to get the fighter's share of whatever food there is." He drew parallels from instances of military blockade in history, and asserted that "food denial in war affects the fighting men least and last, if at all, and is, therefore, unsuccessful unless accompanied by military victories by the blockaders. It is hardest on civilians, particularly children and the elderly; where economic class divisions are sharp, it is particularly hard on the poor." [52]

Another article in the same special issue of Scientist and Citizen, by Arthur W. Galston, developed the thesis that—

> * * * When we intervene in the ecology of a region on a massive scale, we may set in motion an irreversible chain of events which could continue to affect both the agriculture and the wildlife of the area—and, therefore, the people, also—long after the war is over.

Galston referred in his article to a letter which he as one of 12 plant physiologists had written to President Johnson (and that had been reproduced in the January 1967 issue of Bioscience, p. 10); this letter had warned that the massive use of chemical herbicides could upset the ecology of an entire region, possibly with catastrophic effects.

Among the possible short-term effects adverse to the ecology and its inhabitants, according to Galston, were the alleged toxicity of cacodylic acid; [53] injury to crops from drifting spray or volatility (there have been about 500 complaints or requests for compensation filed with hamlet chiefs for transmission to the province chief in one area alone);

[51] John T. Edsall. "Introduction." Scientist and Citizen. (Vol. 9, No. 7, 1967), August-September, p. 113.

[52] Jean Mayer. "Starvation as a Weapon." Scientist and Citizen. Op. cit., pp. 119, 121.

[53] Throughout the course of the technological assessment of military use of herbicides in Vietnam, one element at issue was the toxicity of these chemicals to man and animals. Cacodylic acid was singled out because it contains the element, arsenic, within its complex molecular structure. Since most arsenic-containing compounds are highly toxic to man and animals, the assumption was made that cacodylic acid had this characteristic. However, the MRI Report, after surveying the literature on this point, observed (p. 164): "In the examination of the potential toxicity hazard for this compound, we are particularly impressed by the low oral toxicity." Dr. Tschirley, in his report at Saigon (see pp. 50–52), gives comparative lethal dosage rates of "Agent Blue" (containing 65 percent cacodylic acid) and "aspirin." The terms he used were "LD50" or average lethal dose in milligrams of chemical per kilogram of body weight. The figure for "Blue" is 2600; the figure for "aspirin" is 1775. In his report at Saigon on "Toxicity of Herbicides in Use in RVN," Dr. Minarik asserted that it was "currently being employed at a rate no higher than 9.3 pounds per acre [and therefore], it is safe to assume that there will be no harm to man or animals at these use rates."

Another question raised was as to the "fate" of cacodylic acid. That is, when it decomposed or combined with other materials present in nature, would arsenic be released in toxic form? According to Dr. Minarik's report, cacodylic acid in water was highly soluble and would diffuse rapidly in flowing water. In the soil it would be rapidly deactivated and would cause no residual toxicity problem at the rates used in Vietnam. Since arsenic is widely dispersed in nature, and occurs naturally in the soil at rates substantially higher than that contributed by the spraying of areas at the rate of 9.3 pounds per acre, the additional arsenic from cacodylic acid can apparently be regarded as trivial.

concentration of toxic herbicides, or of toxic reaction products with the soil, in food chains; soil erosion from contaminated soil bared of foliage; wide-scale self-poisoning of plants by toxic products stimulated by the herbicide; injury to fish and wild mammals; and delayed toxicity.

In summary, the Galston article concluded:

> We are too ignorant of the interplay of forces in ecological problems to know how far-reaching and how lasting will be the changes in ecology brought about by the widespread spraying of herbicides in Vietnam. These changes may include immediate harm to people in the sprayed areas and may extend to serious and lasting damage to soil and agriculture, rendering more difficult South Vietnam's recovery from war, regardless of who is the "victor." [54]

The association of herbicides with chemical or biological warfare, germ warfare, poison gas, and other "inhumane" weapons was generally characteristic of the numerous letters to the editor and association protests during this period, attacking the use of defoliant chemicals in the counterguerrilla program in Vietnam. To an indeterminate extent, of course, these protests reflected a generalized disapproval of the program itself, and U.S. participation in it. There was also an apparent relationship between the considerable U.S. interest in "arms control and disarmament" as a new intellectual discipline, and the development of criteria to limit the kinds of weaponry used in war or used as "deterrents"; difficulties were encountered in distinguishing between the military use of herbicides to gain military advantage and the use of various chemicals having direct physiological effects on man relevant to warfare, and particularly those coming within the scope of the Geneva Protocol of 1925. [55]

The legal or moral propriety of military use of herbicides derived its justification from grounds of military necessity or effectiveness, the saving of lives of U.S. troops, and the fact that the chemicals employed were in common use in the United States. (The rationale was similar to that used to justify the employment of tear gas (CS) against guerrilla forces; this kind of agent was, in fact, in general use by civilian police forces throughout the world as an antiriot agent.)

Some confusion was contributed, however, by the imprecision of military usage of terms. Thus, the Joint Chiefs of Staff Dictionary [56] defines herbicide as "a chemical compound which will kill or damage plants." Chemical warfare is extended, by definition, to include "employment of chemicals * * * to create a military advantage * * *." Biological warfare is defined as "employment of living organisms, toxic biological products, and plant growth regulators to produce death or casualties in man, animals, or plants or defense against such action."

[54] Arthur W. Galston. "Changing the Environment." Scientist and Citizen, op. cit., pp. 123–129. Dr. Galston was professor of biology at Yale University, past president of the American Society of Plant Physiologists, and president-elect of the Botanical Society of America.

[55] See, for example: U.S. Congress, Senate, Committee on Foreign Relations. Chemical-Biological-Radiological (CBR) Warfare and Its Disarmament Aspects. A Study prepared by the Subcommittee on Disarmament of the . . . , August 29, 1960. 86th Cong. 2d sess. Committee Print. (Washington, U.S. Government Printing Office, 1960), 43 p.; and U.S. Congress, Senate, Committee on Labor and Public Welfare. Chemical and Biological Weapons: Some Possible Approaches for Lessening the Threat of Danger. Prepared for the Special Subcommittee on the National Science Foundation of the . . . , May 1969. 91st Cong. 1st sess. Committee Print. (Washington, U.S. Government Printing Office, 1969), 64 p.

[56] U.S. Joint Chiefs of Staff. Dictionary of United States Military Terms for Joint Usage. (Short Title: JD). (Washington, D.C., U.S. Government Printing Office, August 1, 1965). JCS Pub. 1.

Clearly, by these definitions, herbicides are both chemical and biological warfare agents. However, the same definitions would also encompass the use of [redacted]ricides to control typhus epidemics in relocated refugee camps.

On the other hand, it can be plausibly asserted that the use of tear gas to flush guerrillas from tunnels to face hostile bullets; or the denuding of foliage that conceals guerrillas from hostile fire, are both forms of chemical warfare with ultimately lethal consequences. In these two cases, the chemicals are not the direct cause of death, but can be regarded as an accessory before the fact. Acceptance or condemnation of chemical defoliants on legal or moral grounds therefore appears to hinge on whether those judging the action find the conflict itself acceptable on legal or moral grounds.

Evaluation of the anticrop program appears to have followed somewhat the same rationale. The "scorched earth" policy in warfare tends to be praised when conducted by one's allies—for example, the U.S.S.R. in World War II—and condemned when practiced by one's adversary—for example, the pollution of wells and waterholes during the withdrawal of the Turks from Arabia in World War I.

The introduction of the concept that belligerents share a responsibility for preserving the ecology of the area of conflict is a very recent development. Presumably it is an outgrowth of several contemporary trends: (*a*) the concept of limited war for limited objectives, generally regarded as made necessary by the development of enormously destructive nuclear weapons that enable nations possessing them and their means of delivery to inflict "unacceptable" damage on other nations in a general war for unlimited objectives; (*b*) the enormous potency of modern chemicals, whether used in military campaigns or for civilian pursuits; (*c*) the increased concern of scientists for the protection of the total world environment to preserve its habitability for mankind at large, and (*d*) the recognition that the human population of the earth is expanding at a rapid rate, and is now foreseen to be approaching the limits of the capacity of the earth to sustain.

Increasingly, the criticism of the military herbicide program in Vietnam by some U.S. scientists has focused on the ecological issue. It was stressed by Galston in his article for Science and Citizen. It was the main question considered by the AAAS (as discussed in the section of this study to follow). A strongly worded, forensic statement in Scientist and Citizen in mid-1968 elaborated on this theme with respect to picloram, a newly developed herbicide being introduced for military use in Vietnam. The article stressed the unmatched potency of the herbicide, its longevity and uncertain fate in the soil, the danger of its migration either along food chains or waterborne, the possibility that its extensive application to tropical soils would expose them so as to cause laterization (i.e., a process by which some kinds of soils in the Tropics when exposed to the sun become infertile and too hard to plow), and that death of trees would cause the death of many animal species. Concluded the article: "The military appeal for [i.e., of]

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this herbicide is obvious; pilots spraying it don't have to return for reapplication. But the Vietnamese farmer wants to ret[redacted]"[87]

Also in 1968, Professor Galston took his case against [redacted]y use of herbicides to the scientific community of the United Kingdom. In an article in the British journal, New Scientist, he declared that "The United States, which was the first and so far the only nation to use nuclear energy for military purposes, has recently become the first and so far the only nation to use in war chemicals directed against growing plants." The effects of this action, he said, were unknown and possibly disastrous:

> One must conclude [he wrote] that the ecological consequences of the widespread use of herbicides in Vietnam are unpredictable. We are certainly doing some damage to the ecology of Vietnam; just how much and how long lasting will be discovered only after the "experiment" has been completed."[88]

Earlier, Galston had denounced U.S. plans to "poison the soil" so as to denude completely the vegetation from a strip of land going entirely across Vietnam from east to west.

> This manmade desert [he wrote] separating North from South Vietnam, and presumably serving to prevent infiltration, could have ecologically catastrophical consequences which cannot at present be envisioned.
>
> In summary, we are too ignorant of the interplay of forces in ecological problems to know how far reaching and how lasting will be the changes in ecology brought about by the widespread spraying of herbicides in Vietnam. These changes may include immediate harm to people in the sprayed areas and may extend to serious and lasting damage to soil and agriculture, rendering more difficult South Vietnam's recovery from war, regardless of who is the "victor."[89]

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[87] George R. Harvey and Jay D. Mann, "Picloram in Vietnam," Scientist and Citizen (September, 1968), pp. 165–171. This article was subsequently analyzed in detail by staff members of Dow Chemical Company, producers of picloram. They charged that the authors had been guilty of "inference, misquotation, and misinterpretation of published scientific data." For example, the article declared that "A sheep was killed by a dose of thirty-six milligrams of picloram mixed with 2,4-D.; However, the reference cited as authority for this statement reported that 11 sheep had been treated with 36 milligrams of picloram mixed with 134 milligrams of 2,4-D. per kilogram of body weight, with 5 daily treatments. The results of this experiment were that of the 11 sheep so treated, all became sick and 4 died. Assuming that the average body weight of a sheep was 28 kilograms, this would amount to a total ingestion of 5,000 milligrams of picloram and 20,000 milligrams of 2,4-D over a 5 day period. (Source of the analysis: B. C. Byrd, Marguerite Long, J. H. Davidson, E. E. Kenaga and J. C. Hansen, "Critique of Picloram in Vietnam." (Dow Chemical Company.) September, 1968, p. 11–12.

[88] Arthur W. Galston, "Military Uses of Herbicides in Vietnam," New Scientist (June 13, 1968), pp. 583–584.

[89] Arthur W. Galston, "Herbicides in Vietnam," The New Republic, (Nov. 25, 1967), p. 21.

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IV. ROLE OF THE AAAS IN ASSESSING WAR USE OF HERBICIDES

The American Association for the Advancement of Science was organized in Philadelphia, September 20, 1848, by a group consisting mainly of geologists and natural scientists. Its objects were initially to promote scientific intercourse, stimulate and direct scientific research, and "procure for the labours of scientific men, increased facilities and a wider usefulness." In 1900, Science magazine became the official publication of the association. As American science expanded, specialized societies proliferated in new fields of research, and many of these became affiliated with AAAS; indeed, most had been organized at annual meetings of the parent institution. By 1969, the total membership of AAAS was put at 120,277 and the total membership of the affiliated societies and academies of science exceeded 7 million. In 1946, the association adopted a new (fifth) constitution that redefined its objectives as:

> * * * to further the work of scientists, to facilitate cooperation among them, to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.

Regional divisions of AAAS were established including one for the Pacific region in 1915. It was at a meeting of the Council of the Pacific Division, June 15, 1966, that the issue of war use of herbicides first entered the formal policy deliberations of the AAAS. At this meeting, the secretary presented a communication from E. W. Pfeiffer, associate professor of zoology at the University of Montana. It proposed a resolution for consideration by the council, which read:

Pfeiffer 1966

> Whereas units of the U.S. Department of Defense have used both chemical and biological warfare agents (as defined by U.S. Department of the Army, TM3-216) in operations against enemy forces in Vietnam; and
>
> Whereas, the effect of these agents upon biological systems in warfare is not known to the scientific community; and
>
> Whereas, the scientific community has a responsibility to be fully informed of these agents and their use in warfare because they are a result of scientific research: Therefore be it
>
> *Resolved*, That—
>
> 1. The Pacific division of the AAAS establish a committee of experts in the field of biological and chemical warfare to study the use of CW and BW agents in Vietnam with the purpose of determining what agents have been used, the extent of their use, and the effects on all biological systems that might have been affected.
>
> 2. That the above committee make a public report of their findings at the next meeting of the Pacific division of the AAAS.

The minutes of the meeting reveal that the Pfeiffer resolution had a mixed reception. Eventually, the council decided to refer it—without recommendation—to the national office of AAAS. Even this decision was controversial—being carried by a 9-to-5 vote with several abstentions. During debate on the resolution, members of the council questioned the propriety of having the action taken at a regional meeting, viewed the issue as more properly one for treatment by the National Academy of Sciences, and rejected the proposition in the resolution that the Pacific division had the means to conduct field investigations in Vietnam.

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Organizational Structure of the AAAS

The AAAS is a complex federation of scientists and scientific societies, designed primarily to facilitate the exchange of scientific information. It has six classes of members, general and administrative officers, a council, 21 sections (organized by scientific discipline), 245 affiliated scientific organizations, 48 associated academies of science, and nine committees.

A difficulty in appraising the effect of an action "taken by the AAAS" is that there are many levels at which views can be expressed, but no ready means to obtain a consensus of the entire membership. The large membership of AAAS exists mainly to receive the organization's periodical, Science. Only "fellows," who constitute some 18 percent of the total membership, are eligible to become officers.

The council of the AAAS, consisting of some 530 members, is not elected from the AAAS membership at large. It includes officers of the AAAS (elected by the council); officers of the sections; two representatives each, named from those affiliated societies with more than 100 members; one representative from each affiliated academy of science; and a number of others. Although the members of the council may in general terms be regarded as spokesmen for the disciplines or groups they represent, they are not literally "elected representatives" of the AAAS membership.

The board of directors of AAAS, which is the "legal representative" of the association, consists of the president-elect, the president, and the past president; eight other fellows; and (ex-officio) the executive officer and the treasurer of AAAS. The ex-officio officers are appointed by the board; the regular members of the board are elected by the council.

Positions on issues can be taken by the board, the council, one of the nine committees, by requesting affiliated societies and academies to express their views, or conceivably by referring an issue to a vote of the entire AAAS membership. The board meets four times a year, and can adopt actions at these meetings. The council meets annually (between Christmas and New Year's), and takes up issues at these meetings.

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AAAS Council's Action on Pfeiffer Resolution

As president-elect of AAAS, Mr. Don K. Price, dean of the Kennedy School of Government, Harvard University, was chairman of the committee on council affairs in the fall of 1966. In this capacity, he received Professor Pfeiffer's resolution. During the yearend meetings of AAAS, in Washington, D.C., the committee on council affairs held a public meeting, at which Pfeiffer and others spoke on the subject of the proposed resolution. After this open session, the committee in an executive session decided to modify the resolution before

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introducing it as new business before the council.[60] The resolution as redrafted by [redacted] committee had received Pfeiffer's approval.[61] Its text at that [redacted]ead as follows:

Whereas modern science and technology now give men unprecedented power to alter his environment and affect the ecological balance of this planet; and

Whereas the full impact of the uses of biological and chemical agents to modify the environment, whether for peaceful or military purposes, is not fully known; and

Whereas the major users of these agents on a scale sufficiently large to modify the ecological balance are now the governments of this and other countries: Be it

Resolved, That the American Association for the Advancement of Science—

(1) Expresses its concern regarding the long-range consequences of the use of biological and chemical agents which modify the environment; and

(2) Establishes a committee to study all aspects of such use, starting with the effects of chemical and biological warfare agents, and periodically to report its findings through appropriate channels of the association; and

(3) Volunteers its cooperation with public agencies and offices of government for the task of ascertaining scientifically and objectively the full implications of major programs and activities which modify the environment and affect the ecological balance on a large scale.[62]

The response of the council to the amended resolution was later described by Mr. Price as follows:

After I introduced the resolution on behalf of the Committee on Council Affairs, and told of our discussions with you and your approval of the text which we had adopted, there followed a long and rather vigorous debate. The key points in that debate were as follows:

On motion of Bentley Glass two amendments were voted in the next to the last paragraph of the resolution: the first deleted the words "all aspects of" and the second substituted "including" for "starting with." On the former point Bentley urged that no committee could study all aspects of so tremendous a problem, and he particularly urged that such a committee not undertake to deal with the political aspects of, for example, biological and chemical warfare. Dr. Rapoport and I both argued against this interpretation, holding that it should be possible to study scientifically the political aspects as well as—although perhaps not as objectively or rigorously as—any other. That particular amendment I believe carried more because others thought that the whole field was an impossibly broad one rather than because anyone wished to exclude any particular aspect of the problem. The other revision (the substituting of "including") was defended on the argument that the committee's hands should not be tied with respect to its own judgment of priorities and that the council itself should not prejudge the issue of priorities. Both of these amendments were carried by a vote that was so overwhelming that no one demanded a specific count.

Two, a council member whose name I do not know, objected to the identifying of "the governments of this and other countries" as the principal offenders, on the argument that industrial corporations and, indeed, private citizens and private automobiles were responsible for much of the pollution of the environment. He moved to strike out the third "whereas."

And again this motion was carried by a very heavy majority.

Three, Ted Byerly of the Department of Agriculture then moved to table the entire resolution, denouncing it as watered down and weasel worded, but adding that—if I remember his language accurately—he did not like the original resolution (referring to your own) any better. The vote on this was close enough so that we could not make a sufficiently accurate count from the platform on a show of hands but had to appoint tellers to walk down the aisles to be certain. But the motion to table lost and the amended resolution was then carried although by a vote that seemed to me reasonably close.

While I am sure you would have preferred not to have these several amendments adopted, I am inclined to think that—Judging from the close vote which prevented the tabling of the amended resolution—the amendments were necessary to the passage of the final vote. I am sure that a number of [redacted] like Bentley Glass would have voted against the unamended resolution, [redacted]reat many more against the resolution in your original form. There is a[redacted] a question whether compromises are worth it in order to get something passed, but I hope that you will feel that something useful may yet come out of this effort.[63]

In reply, Professor Pfeiffer professed himself "pleased" with the final product.[64] The closeness of the division on final adoption of the twice-amended resolution by the council is indicated by the vote: 125 to approve and 95 opposed. In its final form, as approved, the resolution read:

Whereas modern science and technology now give man unprecedented power to alter his environment and affect the ecological balance of this planet; and

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(3) Volunteers its cooperation with public agencies and offices of government for the task of ascertaining scientifically and objectively the full implications of major programs and activities which modify the environment and affect the ecological balance on a large scale.[65]

Implementation of the 1966 AAAS Resolution on Herbicides

In its final form, the resolution dealt primarily with the issue of environmental impairment on a global basis, and only very secondarily with military use of herbicides. Also, while Pfeiffer had sought an actual scientific field investigation by qualified ecologists under AAAS sponsorship in Vietnam, the AAAS Council had been content to express concern over the long-range consequences of the use of chemical and biological agents (whether public or private) that modify the environment, to establish a committee to study the general question, and to volunteer AAAS's cooperation with the Federal Government to identify implications of major programs that "modify the environment and affect the ecological balance on a large scale."[66]

The council action on the amended Pfeiffer resolution was reported to the AAAS membership without any particular emphasis.[67] The first implementing action in response to the resolution was the formation by the AAAS board of directors of an ad hoc committee on environmental alteration, during its meeting March 11–12, 1967. The committee was

[60] Letter from Price to Pfeiffer, Jan. 3, 1967. It is Dean Price's recollection that he discussed the matter with Professor Pfeiffer after the open hearing and before the Committee meeting, and that Pfeiffer left town before the Council meeting.
[61] Letter from Pfeiffer, to Price, Dec. 27, 1966.
[62] Minutes of the Meeting of the AAAS Council, Washington, D.C., Dec. 30, 1966, pp. 7–8.

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[63] Letter from Price to Pfeiffer, Jan. 3, 1967, Op. cit.
[64] Letter from Pfeiffer to Price, Jan. 9, 1967.
[65] Minutes of the Meeting of the AAAS Council, Washington, D.C., Dec. 30, 1966, Op. cit., p. 9.
[66] In comment on the foregoing section, by letter of July 7, 1969, to Mr. R. A. Carpenter, Dean Price suggests that the foregoing account of AAAS deliberations, while "accurate as far as it goes," is "misleading in that it tells the story only from the point of view of Vietnam and Dr. Pfeiffer." He observes that many members of the AAAS board held the view that the Association for several years had been concerned as to the relation of science to environmental problems and saw the Pfeiffer resolution as falling into this context. In retrospect, Dean Price continues, "* * * Personally, I think it was a mistake to combine the two issues (general concern for environmental pollution and the special problem of Vietnam)." Moreover, the newsworthy aspect of the latter issue caused a disproportionate amount of attention to be given it. As Dean Price says: "* * * The newspaper coverage ignored the clear intent of the Council and portrayed the resolution as if it had been aimed at the Vietnam war."
[67] Dael Wolfle (AAAS executive officer), "AAAS Council Meeting, 1966," Science, (Feb. 1967), pp. 855–856.

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chaired by Dr. Rene Dubos, Rockefeller University. Its members included Pfeiffer and Mayer, who had been active in the herbicide issue. When the ad hoc committee reported, in May, it recommended establishment of a continuing AAAS "Commission on the Consequences of Environmental Alteration," and discussed three examples of problems with which the commission should be concerned. These were chemical agents, chemical fertilizers, and waste recycling. The commission should have as its objectives the improved management of information and education on environmental factors, and the design of large-scale controls and emergency measures relative to major aspects of environmental impairment.

With respect to "chemical agents" the Dubos committee identified four of importance: pesticides (to control insects), herbicides (to control weeds), crop-destroying chemicals (to deprive an enemy of food), and defoliating agents (to facilitate harvesting and to improve visibility). The committee recommended that studies of the use of these agents be made "in selected areas where massive programs are in progress." In particular: "In Vietnam such agents are being introduced most intensively; therefore this is a region where the ecological effects may be expected to be most marked."

> The recommended studies [said the report] would involve continuing review, collection, and analysis of information and reporting of findings of the ecological consequences of such massive intervention (for example, effects on nutrition and health, degree of accumulation of the chemical agents in various links of the food chain, shifts in distribution of animal and vegetable species, patterns of recovery of trees and other organisms). The short-term consequences should not be neglected in these studies, but special attention should be given to long-term ecological changes, for altogether too little attention has so far been given to the long-term effects of massive intervention in the environment.

The committee offered a number of suggestions as to ways in which the proposed Commission should conduct its affairs. In particular, it said:

> On occasion, it may be desirable for the Commission to make arrangements to have studies conducted by others. We recommend that the board of directors [of AAAS] consider requesting the National Academy of Science to arrange a continuing study and scientific record of the effects of chemical and biological warfare agents on soil, biota, and human health.

However, one member of the committee, E. W. Pfeiffer, took exception to this suggestion. In a separate, "minority" statement, he said he did not believe that the National Academy of Sciences was "a truly independent organization of scientists" because it had been identified (in Science, Jan. 13, 1967) as a "source of advice for the biological warfare effort * * * and had also been involved in a postdoctoral research fellowship program sponsored by Fort Detrick" [biological warfare research center], for which candidates were "screened by the Academy" and "permitted to describe themselves as having received a NAS–NRC fellowship."

Implementation of Recommendations of the AAAS Ad Hoc Committee

Upon receipt of the ad hoc committee's report, the AAAS board of directors at its meeting in June 1967 decided to divide the general problem into two parts; one was the general question of the consequences of environmental alteration, and the other the specific question of the use of chemical and biological warfare agents in Vietnam. The Board voted to ask the AAAS Committee on Science and Promotion of Human Welfare to "assume continuing responsibility for advising the board concerning developments, actions, or proposals for action that appear likely to result in major alterations of the environment, and from time to time, as the committee considers appropriate, to recommend that the board appoint special commissions for the study of particular actions or proposals." The board would then "appoint groups of persons especially qualified in each such area selected for study and report." [68] The board itself agreed to accept responsibility for the next stage of action on the specific question of military herbicide use in Vietnam.

Implementation of Recommendation for Ecological Field Investigations

With respect to "the more specific question of the use of chemical and biological warfare agents in Vietnam," the board recognized that "no effective study of the effects of such agents could be carried out in an active theater of war without military or other official permission and sponsorship." It therefore instructed the AAAS president (Don Price) and the executive officer (Dael Wolfle) to urge appropriate officers of the Federal Government to arrange for a thorough study under official auspices. Accordingly—

> Conferences on this proposal were held with Frederick Seitz, who is Chairman of the Defense Science Board as well as President of the National Academy of Sciences; Donald Hornig, Director of the Office of Science and Technology; and Donald MacArthur and Rodney W. Nichols of the staff of Robert S. McNamara, Secretary of Defense. Following these conferences, the AAAS president wrote to Secretary McNamara, urging that a study by an independent scientific institution or committee of both the short- and long-range effects of the military use of chemical agents which modify the environment be authorized and undertaken.[69]

The letter to Secretary McNamara recognized that "decisions regarding the use of [chemical agents which modify the environment] in various circumstances must be made in the light of tactical and strategic considerations: but that nevertheless, the "consequences of their use may have such long-range social, economic, and political consequences, both in Vietnam and on the world scene, that the problem warrants study under the highest responsible political auspices." The letter suggested that the National Academy of Sciences-National Research Council would be an appropriate institution for this purpose; an independent commission responsible to the Secretary of Defense or to the President's Science Advisory Committee would be an acceptable alternative. The letter concluded by offering "any assistance it could in such an undertaking, either by sharing in its formal sponsorship, or by advising in the selection of those who are to carry out the study." [70]

The AAAS letter of September 13, 1967, was answered by Dr. John S. Foster, Jr., Director of Defense Research and Engineering, Sep-

[68] Circular letter from Dael Wolfle, executive officer, AAAS, to members of the AAAS Council, Nov. 1, 1967.
[69] Idem.
[70] Letter from Price to Secretary McNamara, Sept. 13, 1967.

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ember 20. First, he dealt with the present state of knowledge concerning the "[redacted]t- or long-term ecological impacts" of the use of herbicides or[redacted]iant chemicals in Vietnam: Whether such impacts existed, and w[redacted]ther they were detrimental or advantageous, he said, was not definitively known. Then he went on—

> Qualified scientists, both inside and outside our Government, and in the governments of other nations, have judged that seriously adverse consequences will not occur. Unless we had confidence in these judgments, we would not continue to employ these materials.

In view of the uncertainties remaining, Dr. Foster said he had taken two steps. One was to commission a "leading nonprofit research institute to thoroughly review and assess all current data in this field." The other was to request the National Academy of Sciences-National Research Council to assemble a group of professionally qualified experts to "review the results of the study and to make appropriate recommendations concerning it." Dr. Foster made clear that he expected no definitive answers from these actions. Instead, they should be considered the first of a number of necessary steps. The study he had commissioned should provide—

(1) A comprehensive compilation of available information;
(2) An assessment of the current information gaps;
(3) Inferences concerning any possible ecological impacts; and
(4) A basis for planning.

Upon completion of this effort, Dr. Foster suggested, there should be a consultation concerning its findings between the Department of Defense and the AAAS leadership, in order to define next steps to be taken. The report was scheduled to be completed by mid-December, to enable its examination by the AAAS Council and board of directors in advance of the association's annual meeting.

Dean Price responded for the AAAS board, October 26. He expressed gratification that the contractor's report and the National Academy of Sciences review would both be available before the AAAS Council meeting in New York City, "between Christmas and New Year's." He also asked Dr. Foster to elaborate on the sources of informed opinion that had led to the conclusion by the Government "that seriously adverse consequences would not occur from the current use of herbicides and defoliants." In reply, November 10, Dr. Foster said the conclusion derived from a "consensus of informed opinion" of some 50–70 individuals, in the absence of "hard data." Nevertheless, he said, "we remain convinced that our judgments were, and are, reasonable and take account of all significant data."

The Midwest Research Institute Study of Ecological Effects of Herbicides

The selection of a contractor to perform the function envisioned by Dr. Foster in his letter of September 20 had already been completed at that time. The contractor was the Midwest Research Institute, located in Kansas City, Mo. The qualifications of the contractor included: (*a*) general familiarity of its personnel with the chemistry of herbicides, as a result of earlier work for the Food and Drug Administration on the establishment of standards for pesticide residues in foodstuffs; (*b*) absence of any past participation in the development of herbicides for military use; and (*c*) a generally sound reputation for technically reliable work in chemically or[redacted]d research. According to the report, the contract ran from August[redacted]December 1, 1967.[71]

The work statement for the MRI contract read as follows:

> The contractor shall review available data and information concerning the ecological consequences of extensive and/or repeated use of herbicides. Primary attention will be given to 2,4-dichlorophenoxyacetic acid, 2,4-5-trichlorophenoxyacetic acid (including their various forms such as the butylesters), cacodylic acid, and Tordon (trade name of Dow Chemical Co.). Data to be reviewed includes published literature, but other sources such as Federal departments and industries must be used to the fullest extent.

Simultaneously with the research project underway at Midwest Research Institute, the staff of the AAAS were undertaking a bibliographic research program of their own, in response to instructions from the board of directors at the fall meeting. Letters were sent to about 100 organizations and individuals requesting bibliographic lists on the subjects of herbicides and defoliants. This action was in connection with the 1966 council resolution "that the association undertake a study of the long-range consequences of the use of biological and chemical agents which modify the environment, [and that it] report periodically its findings, and volunteer its cooperation with public agencies and offices of government for the task of ascertaining scientifically and objectively the full implications of major programs and activities which modify the environment and affect the ecological balance on a large scale."[72] Although the AAAS office in Washington, D.C., accumulated considerable bibliographic information in response to this request, no further action was taken with specific reference to these data. One of the respondents, in fact, observed that "Your request for information simply duplicates the efforts of the Midwest Research Institute."[73]

Cross-Pressures Within AAAS, December–January, 1967–68

The MRI report had not been available to the board by the time the AAAS convened in New York City for its annual meeting. At the AAAS Board meeting, December 29, it became known that the committee on science in the promotion of human welfare, under the chairmanship of Dr. Margaret Mead, had concluded that it had more than enough work already before it, and that the importance of the environmental issues identified by the Dubos committee warranted the establishment by AAAS of a new permanent committee. Accordingly, the board at this same meeting decided to establish a new permanent committee on environmental alteration "and proceeded on the spot to name a few members (some at least of whom were in the room.")[74] The new

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[71] Evidently, staff personnel in the Office of the Director of Defense Research and Engineering attached importance to being able to assert that this action had been taken in advance of a formal request from the Board of Directors of AAAS. Staff members of ODDR&E met with Price and Wolfle in late July 1967 to discuss the Dubos report and a draft of the Price letter to McNamara. A two-month delay was requested. When the letter was finally sent, Sept. 13, Dr. Foster was able to reply that a contractor was already at work on the requested assessment program.

[72] Extract from sample letter, among a group sent out Nov. 7, 1967, reproduced in Memorandum to AAAS Board of Directors, Dec. 21, 1967, by William T. Knibsch.

[73] Ibid., p. 3.

[74] Letter from Price to Carpenter, July 7, 1969. Op. cit.

committee was instructed to "carry on a continuing evaluation of the implications of technological intrusion on environmental processes and their interactions with human population; and, in view of the previously expressed concern of council regarding the use of chemical and biological agents in Vietnam and elsewhere, to request the committee to consider these problems as its initial order of business." The committee was to be under the chairmanship of Dr. David R. Goddard, provost of the University of Pennsylvania, with Dubos, Dr. Barry Commoner of Washington University, and Dr. Athelstan F. Spilhaus, president of the Franklin Institute, initially named as members, with others to be appointed later. The board action was reported to the council a day or two later.

Since the MRI report had been delayed, the council and the board of directors would be unable to participate in a review of it at the time of their convention in New York, at the end of 1967. It was apparently understood that the two issues, which the board had sought to separate, could be brought together once more within the purvue of the new Committee on Environmental Alteration, if the committee desired this; however, the committee had the option of dealing only with broader and less controversial issues of environmental degradation.[75] Apparently there was a good deal of pressure on the new committee not only to deal with Vietnamese herbicide usage, but to make it priority business. Before the MRI report was made available to AAAS, the new committee ran into a snag. Several weeks after its formation, the chairman, Dr. Goddard, resigned, as did Dr. Spilhaus. As reported in Science:

> Both cited extensive professional commitments as the reason for their resignation, though Goddard, in a telephone interview with Science, added, "no sooner was my appointment announced than I started getting pressures from all directions. The emotional overtones were terrific."[76]

Criticism was also expressed over the selection of members of the committee.[77]

Dr. Goddard sent his letter of resignation, as chairman and member of the Committee on Environmental Alteration, to President Price of AAAS, January 24, 1968. The letter illustrates the need for firm, objective leadership in the face of the cross-currents, pressures, and difficulties confronting a science-oriented committee handed a heated

[75] The precise role expected of the new committee with respect to the Vietnamese herbicide issue, and as to whether or not it was a part of the broader environmental issue, is a "matter of interpretation." In comment on this situation, Dael Wolfle has explained that at the September, 1968, meeting, the Board of the AAAS "certainly intended to combine the herbicide issue and the more general matters under the same committee." He adds: "This decision was, I think, a wrong one. It departed from the earlier decision of the Board to keep them separate, a position to which the Board returned at its March 1968 meeting." (In a letter to Mr. R. A. Carpenter, Science Policy Research Division, Legislative Reference Service, July 10, 1969.)

[76] D. S. Greenberg, "Defoliation: AAAS Study Delayed by Resignations from Committee," Science, (Vol. 159, 23 Feb. 1968), p. 857.

[77] Thus, Charles G. Wilber, Colorado State University, complained that "It seems that the individuals were chosen primarily on the basis of their active political involvement in AAAS affairs." He suggested that "the fact that an individual is concerned about a given problem in no way qualifies him to make judgments on that problem." He also expressed the hope "that the power structure in the AAAS will take a second look at this committee and ensure that at least one individual who is competent in the scientific aspects of chemical warfare will be included as a voting member * * *." (Letter to the editor, Scientific Research (Mar. 18, 1968), p. 8.)

political issue. Because of the bearing of the letter on the whole problem of technological assessment in a political environment, the body of the letter is reproduced in its entirety, as follows:

> DEAR DON: This is to inform you that I am resigning as a member and chairman of the AAAS Committee on the Alteration of the Environment. It is with great reluctance that I have come to this conclusion. The decision was not an easy one to make and was based on two factors. One is that of severely limited time: I should have realized earlier that the enormous demands required of the chairman of the committee would conflict with my heavy academic administrative duties at the university. The other is that of the Vietnam issue: already this issue is creating tremendous pressures for the committee, not only more time consuming and difficult but which will also endanger its very purpose.
>
> When we set up the committee we were concerned with intellectual and practical problems of environmental alteration, whether they resulted from the population explosion, from modern industry, from automobiles, from the overuse of pesticides and herbicides, or from the excessive use of agricultural fertilizers. The AAAS was concerned that it should not become directly involved in politics and that it had a role to play in pointing out to the public and the Government ways in which scientific knowledge should be the basis for governmental action. It also recognized that we were going to have to deal with the problem which has arisen in Vietnam due to the use of chemical agents, particularly herbicides, by the Department of Defense. However, we did not want the basic life of the committee to be overwhelmed by this particular problem.
>
> It appears that I was naive concerning the political pressures in relation to the Vietnam problem. Someone, probably someone connected with the Department of Defense, leaked the report of the Midwest Research Institute to the New York Times even though the report has been denied to the AAAS until the National Academy of Sciences evaluates it. It is clear that it is going to be extremely difficult to obtain an impartial view of the report.
>
> One might think that professional scientists would not expect the committee to reach conclusions before it has received scientific evidence, but this is clearly not the case. The correspondence reaching my desk, and the telephone calls—many of them from very distinguished scientists—indicate that many people have prejudged the issue before any committee can be formed. Outsiders are trying to determine the composition of the committee and the conclusions that it will reach. If this seems exaggerated, I would refer one to Luther Carter's article in Science, January 12, 1968.
>
> Anyone who knows me knows that I would be unwilling to chair a committee that would either whitewash the Department of Defense or would reach conclusions before scientific evidence was presented to it; I would also be unwilling to serve on a committee that was organized in advance to condemn the Department of Defense without adequate data. Though I have serious doubts of the military necessity, or the morality of the American participation in Vietnam, if I am to serve on a AAAS committee I must do so as a free agent. The political climate within the membership of the AAAS is such that I do not believe that an impartial study can be made. I am also afraid that the Vietnam war and the emotions that it creates makes difficult any attempt to really evaluate the other important problems of the alteration of the environment.
>
> I realize that my delay in reaching these conclusions has caused difficulties for the AAAS. I can only wish it every success and hope that a committee can be set up that can be of value not only to the AAAS but to American society.
>
> With my best wishes to the officers and directors of the association,
>
> Sincerely yours,
>
> DAVID R. GODDARD.

The article by Luther J. Carter to which Dr. Goddard referred in his letter was an attempt to specify the task of the new Committee on Environmental Alteration, and to indicate the nature of the challenges that faced it. It opened by stating that the first order of business of the committee would be "the ecological impact of chemical

agents used in Vietnam and elsewhere." Factors in this consideration would be the MRI study and the NAS–NRC review of it. The positions of the Department of Defense and leading critics of herbicides in war were identified. One item of criticism of the committee cited by the article was that of Dr. Pfeiffer. According to Carter:

> Pfeiffer feels that, while the new committee is chaired by David R. Goddard (provost of the University of Pennsylvania) rather than by Dubos, it is essentially a continuation of the ad hoc committee under a new name. His confidence in it will be greater, he said, if among the members to be added are people such as Galston and two Harvard contributors to Scientist and Citizen's issue on chemical and biological warfare—John T. Edsall, a biological chemist, and Jean Mayer, a nutritionist and specialist on the history of public health.

Carter, in his article, observed that among the members of the committee were Barry Commoner, who had been a leader in the scientists' information movement, in which Pfeiffer also had been active. Two other members—Dubos and Athelstan Spilhaus—were members of the science advisory board of Scientist and Citizen, official publication of the Scientists' Institute for Public Information. Also in the article, Carter had volunteered the editorial comment that not much was to be expected of the new committee. As he put it: "Just what role the Committee on Environmental Alteration will play in his matter is undetermined, but it is in the nature of such groups to confine themselves to recommending further studies or action by others." [78]

National Academy of Sciences Review of MRI Report

The haste with which the MRI report was pressed to completion is suggested by the method of its delivery. On November 7, 1967, the NAS Panel met with personnel from MRI and the Office of the Director of Defense Research and Engineering, at which time copies of chapters 1, 2, 3, and 5 were turned over for analysis by the Panel. Then, on December 1, MRI mailed directly to the NAS Panel members complete copies of the report. However, according to the later recollection of William B. House, director of the Biological Sciences Division, Midwest Research Institute, the institute was dissatisfied with the appearance of the document, which had been typed on one side of the page only, making it voluminous in size. Copies of the revised report were received by O.D.D.R. & E. on December 20. These were sent to the NAS Panel to replace the earlier copies. On January 31, 1968, the NAS Panel Report was received by O.D.D.R. & E., and on February 15, the MRI report was made available for distribution by the Defense Documentation Center as a method of public release.

The review of the MRI report by the National Academy of Sciences (NAS) apparently began November 7 and was completed by January 31, 1968. In the meantime, however, as Dr. Goddard had indicated in his letter of resignation, a discussion of the MRI report's findings had appeared in the New York Times 3 weeks earlier, and had apparently stimulated further excitement over the issue. Treatment of the report by the NAS was somewhat noncommittal.

[78] Luther J. Carter, New AAAS "Committee to Study Chemical Defoliants," Science, vol. 159, Jan. 12, 1968, p. 179.

The report itself was a substantial volume, 369 pages multilithed, referencing 147 persons as information sources, with 30 pages listing 1,500 items of bibliographical references. The report made the following findings: [79]

> (1) Direct ecological consequence of herbicide use in Vietnam was the destruction of vegetation, setting a region back to an earlier stage of development, from which the process of restoration would then occur.
> (2) Food chains of fauna and heterotrophic plants would be altered.
> (3) Phytotoxicity of herbicides in the soil was not a consideration, nor were lethal toxicity to humans or wildlife, or concentration of deleterious chemicals in food chains.
> (4) Data on chronic toxicity were incomplete.
> (5) Data on aquatic environmental effects of herbicides were inconclusive and mixed—some favorable and some unfavorable.

The report then identified four important areas of uncertainty that remained:

> (1) The effect of 2,4-D and 2,4,5-T on water quality.
> (2) The possible threat to mammals and birds already approaching extinction.
> (3) Micrometeorological effects of forest denudation.
> (4) Possibility of exposing lateritic soils, such as to result in their hardening and infertility.

Review of MRI Report by National Academy of Sciences

In accordance with the understanding between the O.D.D.R. & E. staff and the board of directors of AAAS, the NAS Review Panel was to comment on "the thoroughness and accuracy with which the scientific literature relating to herbicides and their ecological effects had been examined and evaluated."

The NAS assessment (presumably drafted by the Chairman of the Review Panel) [80] noted that the Panel had not functioned as a committee "in the usual sense" because they "did not have an opportunity to meet as a group after the final report was made available." They had, however, "provided specific comments and advice on early drafts of chapters in the report and, after completion of the first full draft, submitted corrections, suggestions for deletions and additions, and general comments." The consensus of the Panel was as follows:

> (1) Midwest Research Institute has done a creditable job of collecting correctly abstracting, and citing much of the relevant published information although, under the circumstances, the report could not be expected to cover in a truly comprehensive way so vast a literature.
> (2) Of necessity, the preponderance of the material deals with herbicides as they are used in vegetation management in a diversity of situations and environments. On this general topic, abundant data are available. However, the scientific literature provides markedly less factual information on the ecological consequences of herbicide use and particularly of repeated or heavy herbicide applications. The Midwest Research Institute report correctly reflects this disparity.

In transmitting the report to Dr. Foster, January 31, 1968, the President of the National Academy of Sciences, Frederick Seitz,

[79] Paraphrased from MRI report, Op cit., pp. 290–292.
[80] The panel was chaired by Dr. A. S. Crafts, University of California at Davis. Members were: Dr. Keith C. Barrons, director, Plant Science Research and Development, Dow Chemical Co.; Dr. Richard Behrens, department of agronomy and plant genetics, Univ. of Minn.; Dr. William S. Benninghoff, department of botany, Univ. of Mich.; Dr. William R. Furtick, department of farm crops, Oregon State Univ.; and Dr. Warren C. Shaw, crop research division, Agricultural Research Service, U.S. Dept. of Agriculture. The MRI report was submitted to the President of the NAS, Jan. 29, 1968.

expressed the view that "it is clear that the compilation of this report is only a [redacted] step in investigating further the ecological effects of intensive [redacted] of herbicides. Some research in this area is now under way but much more needs to be done." Dr. Seitz indicated that "the Academy will be glad to participate in any useful way in the planning and promotion of such research."

Attached to the Panel report were 16 excerpted comments by members, not individually identified, that the chairman judged to be "informative and illuminating." These are briefly summarized as follows:

A good job, particularly considering the short time in which they had to conduct the study and prepare the manuscript.

There is a need for short-term [ecological] studies [including determination of residues in fish].

* * * A substantial report in the restricted time available * * *. However, the report cannot be considered a complete compilation of the available scientific literature on herbicides or the ecological consequences of herbicide usage.

Unfortunately in ecological evaluations quantitative conclusions must in most instances give way to qualitative judgments based on past experience.

(Questioned the "areas of uncertainty" cited by the MRI report.)

(Difference in biomass between Vietnam and temperate regions exaggerated.)

The entire section evaluating the major ecological questions and making a judgment on each one is sound in all respects. It is conservative, yet not excessively so. * * * The problem of soil laterization [may not be real].

I am very favorably impressed by this entire section of evaluation.

* * * Reasonably accurate and fairly comprehensive review of the literature. (However, noted that there was a dearth of literature directly pertinent to the title of the MRI report.)

Ecological consequences of herbicide use, which is the main theme for the manuscript, suffers most from the inadequacy of the information available to actually present an assessment.

* * * A more adequate job could have been done in reviewing current research under way to strengthen information on ecological aspects of herbicide use.

(The report did not consider a wide array of projects by the Department of Agriculture bearing directly on the relationship of herbicides to the environment.)

* * * An enormous number of hours researching the literature and developing background understanding of the field of herbicides. * * * Put together as a result entirely of knowledge gained through literature review without a working background in the field involved. (Frequent oversimplifications but reasonably thorough and authentic.)

(Evaluation by NAS is based on currently used herbicides.)

(Insufficient knowledge available about movement and persistence of picloram in soils and water.)

(Concern for lateralization is exaggerated; soils are not laid bare by herbicides.)

Press Reception of the MRI Report

In the professional press, the MRI report had a mixed reception. Dr. Fred H. Tschirley, an authority on herbicides with the U.S. Department of Agriculture (Assistant Chief, Crops Protection Branch, Agricultural Research Service, USDA), called it a well-done literature review but "disappointing because its direct applicability to Vietnam is so tenuous." [81] Ecologist Frank E. Egler, who had pioneered in the use of herbicides in Connecticut, complained of the study that "Neither the published literature, nor the scientific knowledge allow us to make an assessment of long-term ecological effects of extensive or repeated use of herbicides." [82] Howard T. Odum, of the University of North Carolina, observed that "Data on Vietnam ecosystems are not in this volume." [83] Science News titled a description of the MRI study "The Nondefinitive Report." [84]

Reception by the general press was also diffused and inconclusive. Time magazine concluded from the report that there was "no evidence that there will be long-range damage to plant or animal life in South Vietnam." [85] Newsweek was more explicit: "Even with the institute's voluminous report in hand, neither the Pentagon nor the AAAS is likely to be satisfied entirely." In fact, the article continued, "The real evaluation—in the field—must await a quieter and safer time for scientists in Vietnam." [86]

Thomas O'Toole, in the Washington Post, had his story headlined "Defoliation Threatening Viet Wildlife." [87] William Hines' story in the Washington Evening Star, was headlined "Defoliation Study a Bit Hazy—Vietnam effects unclear." [88]

A succession of headlines in the New York Times illustrates the equivocal effect of the MRI study. Thus, on January 7, a preliminary report on the study before it had been released was headlined: "Report on Vietnam Defoliation Sees Little Damage." [89] A second, February 13, by Walter Sullivan was headlined "Defoliation Study Casts Doubt on Long-Term Damage in Vietnam." [90] A third, February 18, read "Scientists Study Defoliated Areas, Report Concludes Rocklike Laterite Could Result." [91] And a fourth, also by Sullivan, read: "A Look at a New Victim of the War, Plantlife." [92]

It is possible that much of the news comment about the report was prepared on the basis of a short summary of its contents prepared by Dr. Hayward of the office of the Director of Defense Research and Engineering and released around February 1, 1968. The full MRI report and the accompanying NAS analysis were not released until February 15.

In the opinion of Dr. House, "* * * The press, at least to my knowledge, [were] addressing themselves to a release before the report itself was available. Although it mentions in the release that it was a 369-page "state-of-the-knowledge" survey, I feel that some of the comments coming from the press might have been slanted in a different way if they had been reporting directly from the report itself. The report carried a considerable amount of factual data and our philosophy in approaching this problem could not be adequately expressed in a 4½-page summary." [93]

By the latter part of February 1968, there was a good deal of confusion as to the status of the "technological assessment" that the AAAS had undertaken in response to Dr. Pfeiffer's communication. This state

[81] "Reviews," Ecology (Vol. 49, No. 6), p. 1212.
[82] Idem.

[83] Idem.
[84] Vol. 93, 24 Feb. 1968, p. 185.
[85] (Feb. 23, 1968), p. 70.
[86] (Feb. 26, 1968), p. 56.
[87] (Feb. 11, 1968), p. A–1.
[88] (Jan. 31, 1968), p. A–7.
[89] (Jan. 7, 1968), p. 3.
[90] (Feb. 13, 1968), p. 4.
[91] (Feb. 18, 1968), p. 3.
[92] (Feb. 25, 1968), p. 9.
[93] Letter to Mr. Carpenter, op. cit.

formed to inve[illegible]e uses of chemical and biological agents. Pfeiffer has offered to serve and is now planning to bring pressure on the association to sponsor an extensive symposium on the subject. The Scientists' Institute for Public Information in New York will be enlisted by Pfeiffer, although another group—Physicians for Social Responsibility—has already offered to help. This group has had experience of firsthand field research in Vietnam, having visited hospitals there. If the AAAS won't sponsor the symposium, said Pfeiffer, another organization like the International Red Cross or the World Health Organization will be approached. "The symposium would hopefully stimulate people to go into the field and get data on the effects of herbicides. This should include Vietnam in areas which are not continually under fire," Pfeiffer said.[26]

Thus, by the first half of 1968, the problems of conducting a technological assessment by a large association of scientists had been identified as complex and formidable.

There was the importance attached by many leaders of the scientific community to the preservation of the canons of scientific objectivity, which meant avoiding resolution by scientists of technical issues into which a considerable element of political controversy had entered.

There was the problem of screening out of the controversy the bias of those who were opposed to all forms of participation by the United States in the Vietnamese conflict, and who rejected out of hand the defoliation program as merely one more manifestation of a program to which they objected on broader political grounds.

There was the tendency of some scientists to regard the organizational relationships of the Department of Defense, the military departments, the personnel with scientific training in Defense posts, and the military contractors and their scientific personnel, as all involved in a conspiracy to defend and justify programs simply on grounds of short-term military expedience.

There was the fundamental difficulty that the sciences contributing to ecology were insufficiently developed to permit definitive findings as to the long-range impact of herbicides even in the United States where they had been used for more than two decades; so that an assessment of repeated and possibly heavier application of herbicide sprays in an altogether different ecology, under the hazardous conditions of a diffused guerrilla warfare, posed insuperable problems of definitive assessment.

An assessment of the use of herbicides in Vietnam required (*a*) financial resources to mount an expedition, (*b*) military support for to gain entry to the combat area and receive protection while conducting its onsite examination, and (*c*) staffing by recognized scientists unconnected with any aspect of the defoliation program to establish objectivity and maintain credibility. It had become apparent that the MRI report was only the first step toward such an assessment. While it had eliminated a number of questions it had raised or underlined others. But there appeared to be a growing consensus that further investigation was needed.

[26] Scientific Research (Feb. 19, 1968), p. 12.

(42)

There have been outright attempts to kill the project completely [illegible] went on]. Are American scientists capable of making an independent study or not? So far the situation has been up in the air. You cannot get the AAAS board of directors to commit themselves to such a study, and I don't think the average AAAS member knows that the study was ever being considered.

He regarded the use of defoliant chemicals in Vietnam as a "burning issue" and said: "I hope the new committee can send a group to Vietnam, and that it will include people who are concerned with this issue."[26]

Dean Price saw the role of AAAS somewhat differently:

> Our role is far from finished [he said]. This is a slow process. My own opinion is that we had the choice between the kind of operation that would call for a large staff and large sums of money to do firsthand field research. The AAAS has never done this. We operate by committees and review field work done by others. To do field work in the combat zone is even more difficult.
>
> We could have mounted a protest movement which would have achieved little and which would have been opposed violently by the overwhelming majority of our members. The other way was to get the best scientific study done, and then have a committee of hard scientific competence to review it.[27]

When the MRI report, and the accompanying assessment by NAS, reached the offices of AAAS, early in February, the association was unable to take any immediate action because there was no continuing group in session. However, in March, the board of directors met and voted to accept directly the responsibility to review the MRI report. Arrangements were made to have copies of both the report and the NAS assessment provided to all members; in addition, the AAAS staff was asked to send copies to a number of consultants to secure their comments and advice.[27]

The precise function of the AAAS in relation to the MRI report is not clear. From the point of view of most board members, the important question was the broad, long-range condition of the human environment. The military use of herbicides in Vietnam was decidedly secondary. The latter issue was also so inflammatory that any AAAS committee asked to study both the general environmental condition and the specific issue of Vietnamese herbicide usage, would be under great pressure to deal primarily with the secondary issue. Experience had shown the difficulty of organizing a committee willing to accept both issues.

Once the MRI report had been received, the board decided to accept direct responsibility itself for the assessment of the report and of the Vietnamese herbicide issue. It was not accidental that a number of board members were qualified as biologists or ecologists, specifically

[26] "Chemical War: a hot potato for AAAS," Scientific Research (Jan. 22, 1968), p. 14.

[26] Idem.

[27] These were sent to members of the Dubos Committee, and of the Committee on Science in the Promotion of Human Welfare; they also were sent to nine presumed authorities in the field, of whom only three returned their comments before the June meeting of the Board. However, at the June meeting the Board received the benefits of extended comments from Harold Coolidge, executive director of the Pacific Science Board, who had been in Vietnam a few months earlier, and had met with Vietnamese scientists interested in the ecological effects of the military use of herbicides.

(43)

Glass, Commoner, Hoagland, Steinbach, and Thimann; the biologic sciences have always been strongly represented in AAAS membership and leadership, although not necessarily the particular subdisciplines (tropical ecology, plant metabolism, weed chemistry, and control processes, etc.) most precisely germane to the MRI report and the related Vietnamese issue. On the other hand, the board members reasoned that the board itself could not escape ultimate responsibility for any report generated by the committee of the AAAS, because the public release of any such report would require board review and approval in any case. Moreover, the issue was regarded as less technical than of a general scientific-political-organizational nature. The issue was what AAAS should do about the MRI report, rather than the scientific task of designing a field study of the consequences of the use of herbicides in Vietnam. Finally, the board could, if necessary, obtain the advice of a technical committee or of individual consultants, in handling the matter. Distribution of the MRI report, as described above, would facilitate this.

Assessment of MRI Report by AAAS Board of Directors

In mid-July 1968, the Board of Directors of the AAAS issued its own policy statement on the use of herbicides in war. The statement took the form of a review of the MRI report, together with the NAS commentary on it. The board almost unanimously issued a basic statement, accompanied by three supplementary statements by "some members of the board of directors," and a separate dissent by a single board member who preferred an entirely different analytical approach.

In the basic statement, the board expressed the conviction that "many questions concerning the long-range ecological influences of chemical herbicides remain unanswered." One of these was the extent of long-term deleterious effects of the forest defoliation in Vietnam. They also questioned the use of arsenicals on crops and the "ultimate route taken by arsenical compounds in plants, soil, and animals." Accordingly, they did not "share the confidence expressed by the Department of Defense * * * that seriously adverse consequences will not occur as a result of the use of herbicidal chemicals in Vietnam, insofar as arsenical compounds are concerned." They also took account of the "serious concern expressed by scientists in Vietnam over long-term environmental consequences of the military use of herbicides." Because of the uncertainties in available evidence of these consequences, said the board, "such charges cannot now be answered unequivocally."

Accordingly, the board recommended—

> That a field study be undertaken under the auspices and direction of the United Nations, with the participation of Vietnamese scientists and scientists from other countries, and with cooperation, support, and protection provided by the contending forces in the area. This study, which could well be supplemented by experimental work elsewhere, should provide a detailed environmental analysis of the long-range effects of the agents used and of the steps necessary to secure optimum future productivity of the environment for the welfare of its inhabitants.
>
> Further, we urge that the maximum possible amount of relevant data be released from military security, so that the scientists conducting the study may know the areas affected, the agents used, the dates applied, and the dosages employed.
>
> We express especial concern about the use of arsenical herbicides in Vietnam, and urge that their use be suspended, if it has not already been stopped, until the ultimate fate of the degraded arsenical compounds can be more reliably determined.
>
> We recognize the difficulties involved in the proposed field study; however, it is our hope that the feasibility of such a study may be increased as a result of the current peace talks in Paris.
>
> Finally, we hope the recommended study can be initiated promptly and we proffer the good offices of the association in helping to plan it and to publicize its findings.[98]

One supplementary statement, by Messrs. Commoner, Holton, and Steinbach, declared that the herbicide program should be stopped because (*a*) U.S. experience was not relevant, in view of the higher dosage levels in military use; (*b*) the chemicals inhibited the formation of nitrogen-fixing nodules in leguminous plants; and (*c*) might cause widespread chromosomal damage among plants. Moreover, the use of herbicides raised serious moral and political questions which "ought to be carefully considered in the present national debate on the morality and political wisdom of the war in Vietnam."[99]

A second supplementary statement, by Messrs. Roberts and Thimann, took specific exception to the first supplementary statement, and held that "the use of 2,4–D and 2,4,5–T for defoliation of forest cover probably represents a military device for saving lives that has an unprecedented degree of harmlessness to the environment."[100]

A third supplementary statement, by Messrs. Glass, Hoagland, Holton, Klopsteg, Price, Rees, Rieser, Roberts, Steinbach, and Wolfle, agreed that United Nations sponsorship of the recommended study would be desirable, but insisted that "in case such a course of action is not politically feasible for the United Nations, the U.S. Government should reserve the option of initiating and supporting such a study through some private institution or special panel of independent observers."[101]

A fourth supplementary statement, by John A. Wheeler, a nuclear physicist, expressed the view that 20 years of ecological research would not produce "an order-of-magnitude increase in the available information," and that enough was already known for the immediate policy decision. He recommended greater effort in disseminating herbicide information, issuance by the United Nations of limits on arsenical herbicides, U.S. research on herbicides in the United States, and acceptance of the existing situation in Vietnam in which the local people had the responsibility for deciding the military use or nonuse of herbicides.[102]

A clarifying exchange regarding this action by the AAAS board appeared subsequently in the pages of BioScience, the journal of the American Institute of Biological Sciences. Prof. A. Carl Leopold, of

[98] "On the Use of Herbicides in Vietnam." A Statement by the Board of Directors of the American Association for the Advancement of Science. *Science* (Vol. 161, July 19, 1968), p. 254. Those signing the statement were: Don K. Price, Retiring President and Chairman, Board of Directors; Walter Orr Roberts, President; H. Bentley Glass, President-Elect; Paul E. Klopsteg, Treasurer; Barry Commoner; Hudson Hoagland; Gerald Holton; Mina S. Rees; Leonard M. Rieser; H. B. Steinbach; Kenneth V. Thimann; and Dael Wolfle.

[99] Ibid., pp. 254–255.

[100] Ibid., p. 255.

[101] Idem.

[102] Idem.

the Department of Horticulture at Purdue University, in an editorial statement a[illegible]d that the effects of military herbicide use should be studied; bu[illegible]acted strongly against the position taken by Messrs. Commoner, [illegible]on, and Steinbach: "* * * With 500,000 American men in a killing war in Vietnam, to assert that this herbicide cannot be used in protecting them, when we use 57 million pounds of it per year in our own country, is fantastic." [103] The three AAAS board members whose position Leopold questioned, replied in a joint statement in the December issue of the same journal. They referred to Dr. Foster's assurance to the AAAS board, by letter of September 29, 1967, that—

(1) Qualified scientists, both inside and outside our Government, and in the governments of other nations, have judged that seriously adverse consequences will not occur [from the military use of herbicides].
(2) Unless we had confidence in these judgments, we would not continue to employ these materials.

The respondents insisted that what was involved was scientific judgment: whether the use of herbicides by the military services would in fact, have serious long-term ecological consequences. They went on to suggest that the Leopold editorial "* * * reflects confusion regarding the role of scientific judgment in the social issues which involve substantive questions of a technical nature."

Every technology [their statement continued] involves benefits and hazards; scientific evidence is required to evaluate the extent of the hazard associated with a given benefit. However, a judgment which determines whether the estimated hazards outweigh the estimated benefits is not a scientific matter. Such a judgment must be made by an individual on ethical grounds, and by a society on the basis of political decisions, which it is to be hoped, reflect the moral views of that society. It is perhaps useful to point out that the Government of the United States has already forsworn the use of certain weapons in Vietnam that might conceivably, in the short run, save the lives of some U.S. soldiers: nuclear weapons. The present question is whether the chemical weapons now in use in Vietnam ought to fall under a similar proscription. Leopold is, of course, free to express his own view on the moral judgment, but he, and other responsible members of the scientific community, also have an obligation to refrain from confusing their own moral judgment with scientific fact.[104]

Exchanges of AAAS Correspondence with State, Defense, and United Nations

Following the AAAS board meeting, letters were sent out July 19, 1968, over the signature of Dr. Dael Wolfle, executive officer of the AAAS, to the Secretaries of State and Defense, and to the Secretary General of the United Nations. The letter to the Secretary General transmitted a copy of the statement by the board of directors, and asked that consideration be given to the proposal that the United Nations assume responsibility for a study of the long-term effects of the use of chemical herbicides on the ecology of Vietnam. This, said the letter, would be a "means of insuring objectivity and international participation * * *." The response, August 5, signed by José Rolz-Bennett, Under Secretary General for Special Political Affairs, indicated that the Secretary General offered assurances "* * * that the matter of chemical and bacteriological weapons is receiving his very close attention."

[103] BioScience, (September 1968, vol. 18, No. 9), p. 853.
[104] "Letters," BioScience, (December, 1968), p. 1097.

The response of the Department of State, dated September 3, signed by Charles E. Bohlen, Deputy Under Secretary, to[illegible]te of the fact that "there are differences of opinion on the use o[illegible]in chemicals even among the members of this distinguished group." It recalled that limited studies, already made by Government agencies, had "failed to reveal serious ecological disturbances." It acknowledged, however, that "the ultimate effect of these herbicides can be determined definitively only by long-term studies." Accordingly it favored such a long-term study in Vietnam. However—

Such studies in combat areas are obviously difficult at present. The United States will be happy to cooperate in responsible long-term investigations of this type as soon as practicable. The participants should be selected on the basis of their scientific competence to insure acceptance by the scientific community.

The AAAS letter to the Secretary of Defense expressed gratification at the MRI survey. But it noted that "* * * on a number of points information is lacking or insufficient."

The [AAAS] board has concluded that a study should be conducted of the long-term effects of the use of chemical defoliants on the ecology of Vietnam, and has proposed that that study be carried out under the U.N. auspices. A majority of the members of the board have added a supplementary recommendation that the United States assume responsibility for such a study if the United Nations is unable to do so.

The reply to Wolfle's letter to the Department of Defense, dated August 24, was signed by John S. Foster, Jr., Director of Defense Research and Engineering. It expressed gratification at the interest of the AAAS board, and repeated the earlier assurance that herbicides would not be used if competent opinion found them to have seriously adverse consequences. The letter continued—

* * * We have continued to gather data and to reevaluate all available data and technical judgments. While there are a number of scientific questions left unanswered by available studies, these questions apparently would not be answered by additional, short-term investigations. On balance, we continue to be confident that the controlled use of herbicides will have no long-term ecological impacts inimical to the people and interests of South Vietnam.

Before we started the herbicide program in Vietnam, we spent a year studying the effects of herbicides on experimental plots in South Vietnam. We had also compiled a botanical survey of South Vietnam, a copy of which is attached. On several occasions we have sent scientists, both from DOD and the Department of Agriculture, to South Vietnam to search for evidence of adverse ecological change. The Department of State and AID have also made evaluative surveys utilizing consultants from universities, the Department of Agriculture, and the U.S. Forest Service. To date, all of the reports of these surveys indicate no evidence of serious adverse ecological effects.

Systematic scientific investigation in combat zones is virtually impossible. Substantial military protection is required to secure an area for meaningful study. Therefore we have devoted effort to studies of analogous areas. We supported the Department of Agriculture in a 5-year study of herbicides in areas of Puerto Rico and Texas which are similar to areas of South Vietnam; a copy of the report on these investigations is also attached.

We have benefitted from the experience of others. For example, arsenical herbicides have been used extensively in rubber and oil-palm plantations in Malaysia for over 20 years at application rates 5 to 6 times in excess of those used in South Vietnam, apparently without adverse effects. The arsenical we have used (dimethyl arsinic acid) is one of the least toxic of herbicides to mammals.

We are, of course, continuing our investigations and surveys. I believe we have consistently taken a responsible and openminded approach to the herbicide program of the Department of Defense. As soon as peaceful conditions return to Vietnam, and systematic scientific investigation becomes feasible, we will support additional studies in all ways that are legal and proper.

State Department Attempt at Herbicide Assessment

One official action that seems relevant to the calls for an immediate on-the-spot study of the effects of repeated use of herbicides on the Vietnamese ecology was an assessment under State Department auspices in Saigon during September 1968. Apparently no single vector was responsible for motivating this assessment; rather, it was the culmination of a number of unrelated developments:

The request by the AAAS board of directors that brought in the United Nations, as well as the Department of State;

The fact that Dr. Fred H. Tschirley of the U.S. Department of Agriculture, at the request of the Department of State, had made ecological observations earlier in the year in some areas of Vietnam where herbicides had been used;

The fact that the AAAS board of directors was still in communication with the Department of Defense on the herbicide issue;

The apparent concern of officials of the Agency for International Development (AID) over occasional instances of inadvertent damage to crops from military herbicide spraying operations;

The drumfire of propaganda from Hanoi and Peking, charging the use of "poisonous" herbicides (which the Vietcong guerrillas apparently accepted at face value);

The possibility that "world public opinion" had been influenced by Communist allegations that required contradiction from well-documented sources;

The possibility that South Vietnamese officials and public required some degree of formal reassurance.

Apparently, the herbicide program in Vietnam had been subjected to repeated reviews and assessments within the official U.S. mission to Vietnam. A report by Elizabeth Pond in the Christian Science Monitor, in late 1967, noted that in the spring of that year, "Following damage to rubber trees and to fruit trees, the military command reportedly ran a reassessment of its program and banned some of the more volatile herbicides it had been using and extended the radius of prohibited operations around plantations." A more extensive assessment was in progress in December 1967. According to the story from Miss Pond, "no one in the mission questions the use of defoliants where military gains are clear cut and accompanying agricultural losses are minimal." However, there was uneasiness "about the actual practice of defoliation, about the doctrine and guidelines under which it is carried out." A subjective indicator cited was that "One American official in III Corps, the hardest hit of any of the corps by unintended fallout, gave the judgment that virtually every farmer in that corps knows of the defoliation program and disapproves of it." Accordingly, there was an apparent need for "some workable rule of thumb for measuring potential military gain against potential economic and political loss." The economic officials, she said, "have asked recently for a technical study on the potency and duration of effectiveness of some of the chemicals used." In addition, the mission officials—

• • • would like to run a check on the guidelines now in use on defoliation operations. They would like to reconsider the permitted margin of error, the adjustment to changed conditions due to time lags between conception and execution of operations, and duration of authorization—currently 1 year.

They would like to find out how much the danger of low-altitude spraying affects the other delicate controls needed in mixed forest-cropland areas.

The more extensive assessment by the Department of State that took place during 1968, under the sponsorship of Ambassador Ellsworth Bunker, was reported in Saigon by the U.S. mission, September 18; the text of the basic press release was as follows:

In keeping with the U.S. mission's policy of continually monitoring the U.S. role in Allied herbicide operations in South Vietnam, Ambassador Ellsworth Bunker established a special interagency committee earlier this year to make a comprehensive review of the program. The herbicide program, which is under the overall direction of the GVN and supported by U.S. military and civilian elements, has been an integral part of the allied military effort. The committee's task was to assess the military benefits of the program in relation to its economic costs and to study its effects upon the ecology of the country. The review indicated that in general herbicide operations in Vietnam have been accomplished without significant damage to the ecology of the country and that the military benefits in terms of lives saved and other factors have far outweighed certain known adverse economic effects. The committee, however, recommended certain steps to reduce some of the economic costs as noted below.

Assisting the committee were a number of scientific and technical experts, some of whom were brought from the United States for this study. Among them was Dr. Fred H. Tschirley, an authority on tropical ecology who is with the U.S. Department of Agriculture. He conducted a separate investigation of the ecological consequences of the defoliation in Vietnam. The full text of this study is attached to this press release.

According to the findings of the committee, the use of herbicides around base perimeters, along lines of communication, and against enemy infiltration routes, staging and base areas has, both in terms of offensive and defensive action, reduced the number of men and amount of equipment required for combat missions, secured material and facilities, and, most importantly, helped to save the lives of many Vietnamese and Allied personnel.

The military benefits of the use of herbicides against enemy food sources in food-scarce highland areas in I, II, III corps, the only areas where such operations are conducted, was more difficult to assess. There was, however, considerable evidence that food shortages for which herbicide operations were partly responsible, have created logistical problems for the enemy by causing him to divert human and other resources to noncombat activities.

Economic costs were found to be sizable. The principal cost was in lost or damaged timber reserves and merchantable timber, particularly in war zone D where security conditions have not permitted salvage efforts. There were other, minor economic losses for accidental damage to various crops due to spray or vapor drift, equipment failure, and emergency jettisoning of herbicides. The committee considered it within the capability of the GVN and the USG, however, to reduce and eliminate some of the economic costs of the program, principally through salvage operations and reforestation.

Thus, in weighing the overall costs, problems, and unknowns of the herbicide programs against the benefits, the committee concluded that the latter outweigh the former and that the programs should be continued.

(Also available for information to interested correspondents are copies of several other papers prepared for the committee on a number of technical subjects, including spray drift, the toxicity of herbicides used in Vietnam, and the persistence of herbicides in soil and water.)

Query Response

If asked about implementation of Tschirley's recommendations and/or other information concerning program controls and execution, we would respond, as is necessary and appropriate that: (*a*) Yes, controls and methods of execution of herbicide programs were reviewed; (*b*) No repeat no deficiencies were found that

[26] Elizabeth Pond, "U.S. Officials Review Viet Defoliation," Christian Science Monitor, (Dec. 27, 1967), p. 4.

(d) Details [redacted]ing controls and the implementation of herbicide programs involve security information and cannot be discussed.

Accompanying the official press release at the Saigon briefing were a number of papers that had been prepared earlier. Three of these were unclassified. One was a detailed report by Dr. Tschirley—"An Assessment of Ecological Consequences of the Defoliation Program in Vietnam," dated April 12, 1968.[106] The other two, both by Dr. C. E. Minarik, director of the plant science laboratory and Dr. R. A. Darrow, Chief of the Plant Physiology Division, Department of the Army, Fort Detrick, Md., were: "Toxicity of Herbicides in Use in RVN," dated April 3, and "persistence of Herbicides in Soil and Water," dated April 6.

The Tschirley paper enumerated the scope of his investigation as follows:

> The mangrove vegetational complex was viewed from a helicopter overflight of the Rung Sat Special Zone (RSSZ) on March 18, 1968. Defoliation of the mangrove in the RSSZ was started in 1966, but most of the defoliation flights were made after June 1967. A mangrove area on the Ong Doc River that had been sprayed in 1962 was viewed from a C–123 overflight on April 7, 1968.
>
> Semideciduous forest in war zones C and D were surveyed from a C–123 on March 23, 1968. A more detailed aerial survey was made on March 27, 1968 from a high-wing Porter aircraft. Helicopter flights were also made over many of the same areas, and some new areas, in the course of being transported to and from specific areas that were surveyed on the ground.
>
> Ground surveys were made from Special Forces camps located at Thien Ngon, Katum, Tong le Chon, and Bu Dop from March 29 to April 1, 1968, inclusive. Several hours were spent in the forest at each location to assess defoliation, refoliation, successional patterns, and to get a feel for the possible effects of the defoliation on wildlife. In addition to the personal observations, men at the camps were questioned regarding the effect of defoliation on their operation, their impressions about the relative difficulty of human movement in the forest (a rough measure of the density and composition of the ground story vegetation), and sightings they had made of wildlife.
>
> Aerial and ground surveys were concentrated in war zones C and D because large areas have been sprayed with defoliant in those zones. Portions of C and D zones have been sprayed 2 and 3 times. There are no other areas in Vietnam where such large blocks have been treated or that have been treated so intensively (an exception to that statement would be the DMZ). Thus, the ecological consequences of the defoliation program would be expected to be most evident and most easily defined in those areas. War zones C and D were also accessible for aerial surveys and the location of Special Forces camps afforded the opportunity of close observation from the ground.
>
> A concluding introductory remark is necessary. This report can in no sense be considered a complete, authoritative assessment of the ecologic effects resulting from defoliation of forest canopy. The conclusions reached are judgments based on prior experience and the necessarily few observations that were possible in an area of war activity within the time frame demanded.

[106] Substantially this same paper appeared under the title "Defoliation in Vietnam," Science (vol. 163, Feb. 21, 1969), pp. 779-786. An important addition to the Science article, not included with the paper released in Saigon, was a concluding section of "recommendations" which read:

"(1) The desirability of ecologic research in Vietnam after the war ends cannot be overemphasized. The research should be administered through an institution that will provide continuity and breadth for the research program. The opportunity of establishing ecologic research under the International Biological Program should be explored.

"(2) Continuing assessment of the defoliation program as it affects forestry and watershed values should be made. Ground observations are most desirable, but aerial surveys during various seasons of the year will contribute much good information" (p. 788).

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A. Climatic effects

Alleged effects of defoliation on climate assessed as follows: precipitation, no effect; ground temperature, increased; wind speed at ground level, higher. Summary: no great effect on higher plants and animals; "might temporarily affect lower life forms more dependent on specific microclimatic niches for growth and survival" (pp. 41–42).

B. Effects on soils

Expressed fears of laterization (conversion of soil to hardened, infertile form) assessed as follows: only about 30 percent of Vietnamese soils satisfy the condition for laterization. "Under natural conditions laterization is a long-term process. The process is speeded up when soil is exposed to direct solar radiation and wind. I do not find it reasonable that the defoliation program in Vietnam would hasten the laterization process significantly because bare soil does not result from defoliation" (p. 44).

Possibility of soil erosion: information insufficient for assessment (p. 44).

Possibility of destruction of soil microorganisms: "* * * should have no detrimental effect" (p. 45).

C. Effects on plant and animal populations

(1) Mangrove forest

Trees were killed; "20 years is a conservative estimate of the time needed for this forest to return to its original condition" (pp. 46–47).

"There has been a steadily increasing fish catch." [This suggests that in mangrove areas] the aquatic food chain has not been seriously disturbed" (p. 48).

"It is reasonable to assume that there has been some reduction in bird population" [but proportionately less than the ratio of area treated to total area] (p. 49).

"Effects on other forms of animal life are unknown, but surely the population of invertebrates in particular has been reduced." [But not to the point of extinction.]

(2) Semideciduous forest

Actual area treated is 8,140 square kilometers, plus 460 square kilometers of mangrove forest; this is 16.2 percent of total forest area. Of this, about 10 percent was treated 2 or 3 times. Area studied had been retreated most intensively. [However, this was the dry season, and "there could not have been a worse time to assess the ecologic impact" on semideciduous forests.] For single treatment, no "great or lasting effect" was found, but multiple treatment would have "a far greater effect." [There is little knowledge about relative susceptibility of forest species in Vietnam to herbicides, or about natural regeneration in tropical forests.] (Pp. 49–53.)

"The greatest danger resulting from repeated defoliation treatments in Vietnam is that such areas will be invaded by bamboo" (p. 56).

"The greater the number of herbicidal treatments the greater the harm to animal populations" (p. 58).

The report on herbicide toxicity repeated the findings collected by the MRI report respecting 2,4–D and 2,4,5–T. It found "no synergistic toxicities" in animals as a result of using these mixtures. However, the effect of "orange" (a combination of these two herbicides) might be fatal to fish under some conditions, although "there have been no reports of fish kill attributed to herbicides." With respect to cacodylic acid, it was "currently being employed at a rate no higher than 9.3 pounds per acre, [and accordingly] it is safe to assume that there will be no harm to man or animals at these use rates. The high tolerance of rats, other laboratory animals and fish to this herbicide place it in a safer category than herbicide orange. With respect to picloram "white"

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was not to be considered toxic or hazardous to humans, animals or ish at the use being employed in Vietnam."

The report on herbicide persistence in soils and water identified picloram as the most persistent. However: "In Puerto Rico tests, the mount of chemical remaining 6 to 12 months after direct application to the soil of picloram in amounts four to six times greater than that sed in RVN defoliation operations was insufficient to cause injury planted crop seedlings of all but the most sensitive crop, soybeans." oreover, "As confirmed in bean seedling tests on soils from two RVN rovinces taken from 1966 to 1967 defoliation targets, no persistence herbicide was found 11 to 17 months after single and double applications of white." Agent orange was not persistent in soil, and the hemicals "disappear in 1 to 3 months at the rates of application sed in RVN." Agent blue was "rapidly absorbed and inactivated in oils" so that "susceptible crops can be planted directly in soils within few days after application of cacodylic acid at rates greater than the gallons per acre used in RVN."

The reception among "concerned" U.S. scientists of the data released t Saigon by Ambassador Ellsworth Bunker's interagency committee as not well documented. Dr. Barry Commoner called it "pretty bad."

> The conclusion I reach [Commoner is quoted as saying] is that the people ho distribute the defoliants don't know what they are doing. If the evidence as gathered from the air the damage must be pretty bad.[107]

The interagency study received comparatively little mention at the AAAS meeting in Dallas, toward the end of the year. In particular, r. Pfeiffer, who had been insistently calling for a field study in ietnam of ecological effects of herbicide use, appeared not to regard e Bunker assessment as meeting his requirements.

nited Nations Actions After Appeal from AAAS

Two actions with possible relevance to the AAAS request did occur the United Nations in the fall of 1968. One was the adoption without objection by the General Assembly of a resolution that proposed o convene in 1972 a United Nations Conference on Human Environment. In advance of the conference, the Secretary General was called n to submit a report concerning—

> (*a*) The nature, scope, and progress of work at present being done in the field of human environment;
> (*b*) The main problems facing developed and developing countries in this area, which might with particular advantage be considered at such a conference, including the possibilities for increased international cooperation, especially as they relate to economic and social development, in particular of the developing countries;
> (*c*) Possible methods of preparing for the Conference and the time necessary for such preparations;
> (*d*) A possible time and place for the Conference;
> (*e*) The range of financial implications for the United Nations of the holding of the Conference.[108]

[107] "It's still 'no' on AAAS efforts to launch Vietnam ecological survey," Scientific esearch (Oct. 14, 1968), p. 10.

[108] General Assembly Resolutions, 23rd regular session, Resolution adopted 2398 (XXIII), ec. 3, 1968, 1743rd plenary meeting. In comment on this action, Senator Muskie, Apr. 3, eclared that "The nations of the world must develop ecological consciences, an awareness hat we are all a part of a single ecosystem developed over eons of time. Our alteration f that ecosystem puts a heavy responsibility on man to manage the quality of the environment to assure his own survival and the survival of those other species essential to life on arth." He offered a resolution (S. Res. 179) that the United States should actively support nd participate in such a conference and assist in its formation. (Congressional Record, pr. 3, 1969, pp. S3530–S3531.)

The other U.N. action was an Assembly resolution that, among other things, called upon the Secretary General to "prepare ... concise report * * * based on accessible material and prepared with the assistance of qualified consultant experts" concerning "various aspects of the problem of chemical, bacteriological, and other biological weapons * * *." The report was to be completed, if possible by July 1, 1969.[109]

The position of the United States toward chemical and biological warfare, including herbicides, had been described to the U.N. General Assembly, December 5, 1966, by Samuel M. Nabrit, U.S. Ambassador to the United Nations. He said the U.S. delegation would support the U.N. endorsement of the Geneva protocol of 1925. As understood by the United States, the Geneva protocol of 1925, he said, "prohibits the use in war of asphyxiating and poisonous gas and other similar gases and liquids with equally deadly effects." However, "* * * the protocol does not apply to herbicides, which involve the same chemicals and have the same effects as those used domestically in the United States, the Soviet Union and many other countries to control weeds and other unwanted vegetation."[110]

The AAAS Board of Directors invited to its October meeting, for the discussion of the herbicide issue a number of persons involved in this issue in or for the Department of Defense.[111] At this meeting, a public symposium was planned for the annual meeting of the association, to air views on the MRI report, the Tschirley report in Saigon, and other aspects. Dr. Pfeiffer, who had apparently not been satisfied with either the MRI report or the subsequent Tschirley investigation, a few days after the board meeting, offered to the Committee on Council Affairs a resolution that the council ask the committee on environmental alteration to appoint a subcommittee to conduct the field study called for in the board resolution adopted the previous June.

Renewed AAAS Appeal for Field Ecological Investigation

When the AAAS membership convened at Dallas, at the close of 1968, the status of the controversy over military use of herbicides in Vietnam was as follows:

The Department of Defense had released considerable technical information assertedly relevant to its conclusion that no "seriously adverse consequences" resulted from military herbicide usage; and had given assurance that the assessment program was continuing.

The AAAS board of directors had urged specific reductions in the program, and had not revised this recommendation upon receipt of DOD information.

[109] General Assembly Resolutions, 23rd regular session, Resolution Adopted 2454–A(XXIII), Dec. 20, 1968, 1750th plenary meeting.

[110] Representative Robert Kastenmeier, Sept. 3, 1959, had proposed a resolution (H.Con. Res. 433) that would reaffirm the "longstanding policy of the United States that in the event of war the United States shall under no circumstances resort to the use of biological weapons or the use of poisonous or [noxious] gases unless they are first used by our enemies." Both the Departments of State and Defense opposed passage of this resolution. However, State's opposition was based on the proposition that it was redundant because the United States was already committed to refrain from the use of force of any kind in a manner contrary to the charter of the United Nations. Department of Defense opposition was also based on the further consideration that other countries were actively pursuing programs in this field, and the proposed resolution would possibly "introduce uncertainty into the necessary planning of the Department of Defense in preparing to meet possible hostile action of all kinds."

[111] These were: Messrs. Rodney Nichols and A. E. Hayward of the Office of the Director of Defense Research and Engineering; and Drs. Minarik and Tschirley.

AAAS had been unable to find a way to enlist the resources of the U.N. in the conduct of an on-the-spot study; the study performed by WHO at the instance of the AAAS had been limited to the open literature, and had not involved the collection of onsite data; the State Department's release of data in Saigon had not quieted those who sought onsite data.

Accordingly, in the annual meeting of the AAAS Council, in December 1968, the board of directors announced that the AAAS "would participate in a study of the use of herbicides in Vietnam." An account of the council's response to this announcement, carried in Science, was as follows:

> In a heated meeting in an overheated room on Monday, the board's inclusion of Vietnam in its original resolution was challenged by council members. The attack was opened by James B. Ross, representing the Nature Conservancy, who said that the board should concern itself with other environmental hazards and should not single out Vietnam. A resolution expressing the agreement of the council with the sense of the board resolution to conduct a study of the use of herbicides in Vietnam, but advising changes in the language of the board's original resolution so as to delete mention of Vietnam, was passed overwhelmingly. In passing such a resolution, the council was taking a position similar to that adopted at the 1966 AAAS meeting in Washington, D.C.
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> In accordance with this advice from the council, the board revised its resolution to read as follows:
>
> "It is the sense of the board that the association, looking not only to the effects of the wartime use of herbicides, but also to the opportunities for the peacetime reconstruction of the agriculture and economy of affected areas:
>
> "(1) Determines that it should be a purpose of the association to bring into being the most effective possible field study of the potential long- and short-term ecological risks and benefits in the areas affected;
>
> "(2) Specifically directs the AAAS staff to convene, as soon as possible, an ad hoc group involving representation of interested national and international scientific organizations to prepare specific plans for conduct of such a field study and with the expectation that the AAAS would participate in such a study within the reasonable limits of its resources." [18]

The article went on to note that "At the Dallas meeting of the AAAS, E. W. Pfeiffer of the University of Montana introduced, before the committee on council affairs, a resolution calling for a AAAS study and urging council backing of the board's July statement." There were also papers on the possible backing of the board's July statement. There were also papers on the possible ecological consequences of the use of herbicides in Vietnam presented at a meeting sponsored jointly by the AAAS Committee on Science in the Promotion of Human Welfare and the Scientists' Institute for Public Information.

The technical papers before the joint meeting were presented by Dr. Tschirley, Dr. Boysie E. Day, professor of plant physiology and associate director of the experiment station, University of California (Riverside), Professor Galston, and a panel discussion with questions from the floor.

Dr. Tschirley, in his prepared statement, covered essentially the same material as in his Saigon report. Dr. Day stressed U.S. domestic experience with herbicides—noting that some 100,000 organic compounds were synthesized and tested annually as herbicides, 125 were being marketed, and about 50 were in quite extensive use. There was

[18] Bryce Nelson, "Herbicides in Vietnam: AAAS Board Seeks Field Study," Science (Vol. 163, Jan. 3, 1969), p. 58.

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no relation between herbicidal effect and mammalian toxicity. The hazards to vegetation included "failure of selectivity," changes in climate, soil, rainfall," and "migration of the herbicide from the site." In the United States, he said, the use of herbicides was "highly regulated." The primary discoverer of a herbicide develops toxicity information, develops use information, and supplies this information to an agency of the Government in support of a request for registration. The label, in this trade, he said, was "a sort of a holy document." To obtain the label involved some $3 million of laboratory and field research and up to $6, $8, $10 million in further development. (The implication of this presentation was that before herbicides found their way into military service, they had received an abundance of testing so that their properties were rather precisely known.)

The presentation by Professor Galston took the opposite position. He acknowledged that plant regulating chemicals had been a "really brilliant contribution." However, the "use of any chemical additive carries with it certain dangers." While peacetime society "has safeguards of such use," he warned that "Under military and especially under wartime conditions these restraints can be an autocatalytic process leading to still further transgressions and that it is in this area in which a signal lack of restraints currently bedevils us, and alarms some of us." He was critical of the "bland reassurances" of Defense scientists as to the nontoxicity of military herbicides, and declared that in view of the "great stability" of picloram, its use presented a real hazard of long-term damage to the ecology. "I suspect that great damage will have been done," he said. He voiced again his earlier apprehensions concerning danger to microorganisms in the soil, laterization, and massive erosion from monsoonal rains. Then he warned: "We are continually investigating new chemicals for military use." Moreover, "The restraints in this area and the rules governing the introduction of new weapons into warfare constitute a very great danger for all of us." The initiating action, under combat conditions, is taken by a military officer. There is a clearance procedure, he conceded, but it was not as precise and absolute as with the "big bang weapons." Then he concluded:

> I believe that we have restraints built into our warfare situation regarding the big bang weapons. We know that nobody may use any nuclear device in warfare unless the President of the United States authorizes the pressing of that button. With regard to the chemical agents, the restraints seem much looser and it seems to me that practices that are being conducted in the name of the American people in Vietnam in the way of killing vegetation at the moment have not been subjected to the same kind of searching and restraining curiosity that I personally would like to see. What about the new weapons that are under development now? Who is going to exert control over the use of those? If, for example, a decision is made to kill rice, which feeds populations, as a weapon of war, why, then, resort to the use of chemicals which have to be sprayed by airplane time after time with the danger to the pilots * * *. Why not use an organism to do this?

The panel discussion highlighted some of the difficulties the scientists were encountering in achieving a consensus in the assessment of herbicides in Vietnam. A condensed sampling of the discussion is as follows:

Dr. Commoner: Expressed concern over unanticipated biological hazards. Were there any? Were they anticipated? What steps were

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taken to see that they were anticipated? What was the relation between this report (MRI report) and their military use?

Dr. Day: We know a great deal about herbicides. Picloram does break down in the soil. There have been some 10,000 papers dealing with the effects of 2,4–D, which comes from the "stone age of herbicides."

Dr. Margaret Mead: We are talking about a variant of the "scorched earth policy." Today, there is a "new ethics"—it is a new thing to worry about the welfare of an enemy. We are beginning to realize that we are living on a planet—"a total system." Yet, we have a tendency to worry about small issues.

Dr. Day: "I admit that the world is run on incomplete knowledge." The MRI report gave little coverage of much of the practical literature. "The thing was prepared in 60 days by people who know nothing about herbicides."

Dr. Commoner: "The public revelations about this problem have been characterized by * * * quick and poorly conceived responses to jabs of criticism made by concerned scientists." He referred to Dr. Tschirley's survey as a "30 day quickie look in the dry season." What was needed, he said, was a "long-term continued investigation."

Dr. Tschirley: Was in agreement, but who would pay for it? Could it be made a part of the activity under the international biological program? He complained that the "ecosystem approach" had not been done; there was not much communication between ecologists and other scientists. There was a need to get together with the people who work with pesticides. There was a great deal known about these in the United States. We could admit we need more ecological information. But we can make better use of what we already know. We know very little about ecosystems in any sense.

Dr. Galston: Raised a question about the metabolism of cacodylic acid, and the availability of information about it.

Dr. Day: There was "so much arsenic lying around in nature that it's very difficult to sort out the little bit that we're putting into the system." The effect of arsenic deriving from cacodylic acid applications, he said, was "trivial." Agricultural applications of arsenicals amount to as much as 400 to 800 pounds per acre, whereas cacodylic acid provided only something like 1 or 2 pounds per acre.

Dr. Holton: Expressed concern over the use of an incomplete body of scientific knowledge as the basis for action. He stressed the limitations of the scientific support for policymaking. Nevertheless, he recognized, policymakers have to act. Their decisions, though, should not be made dependent on limited scientific knowledge—scientists should not be made responsible for political decisions taken on the basis of such insufficient knowledge.

Apparent Reduction in AAAS Concern Over Herbicides in 1969

One action in response to the new council resolution was taken by Walter Orr Roberts, who had retired as AAAS president, to become chairman of the board of directors at the close of 1968. He wrote the Secretary of State, January 19, 1969, on behalf of the Association "to request your assistance in making certain that as soon as conditions permit there will be undertaken a comprehensive study of the ecological effects of the use of herbicides in Vietnam." Dr. Roberts expressed the Board's gratification that the State Department had "adopted the recommendations of your consultant, Dr. Tschirley regarding the need for ecological research to be carried out," and said: "We also understand that there is, from your Department, a recommendation for the adoption, prior to the cessation of combat, of a policy of defoliation in strips as opposed to big area defoliation." Finally, he offered the support and assistance of AAAS in preparing for the recommended postwar assessment:

> I am sure [he concluded] that our board and our council will enthusiastically support these steps to control the use of defoliants in Vietnam, and to assess the long-term ecological consequences of the defoliant usage of the past. The AAAS will be very happy to help in any way that we can. As scientists and citizens, we sincerely hope that the steps approved by your Department and our Embassy in Vietnam will be put promptly into effect. We will be very pleased to help to plan or to organize an appropriate ecological study that can be conducted in the field after, very hopefully, the hostilities cease.[113]

By the end of June 1969, it appeared that the AAAS had virtually exhausted its initiatives. The association had obtained assurances from the Department of Defense that herbicide usage would be continually assessed. A general policy had also been established that there should be no long-range and seriously adverse consequences of such usage. Both the Departments of State and Defense had promised support for a postwar ecological investigation of long-range consequences of the military use of herbicides in Vietnam. The United Nations had agreed to sponsor a full-scale international meeting of world scientists on environmental quality. The issue of chemical and biological warfare had been referred by the General Assembly to the 18th National Disarmament Conference in Geneva for consideration as a part of its permanent agenda. Technical cautions had been expressed by the AAAS board concerning the treatment of large areas or blocks of territory; the issues of biodegradability, toxicity, heavy application, and repeated application had been made publicly visible.

On the other hand, the operational role of the AAAS in making ready for long-sought postwar assessment had not yet been defined. Although pledging its support and assistance, the board and council had taken no steps to mobilize AAAS resources for this purpose. A substantial membership roster had been recruited for the new AAAS Committee on Environmental Alteration, but the staff of AAAS have made clear that it was not expected to spearhead the effort.[114]

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[113] In comment on the circumstances leading up to the preparation of Walter Robert's letter, Dael Wolfle notes that "Discussions Roberts had with people in ODDR&E in the days immediately following [the Board meeting of December 1968] led him to decide that we should not, for the time being, convene an ad hoc group (as called for in the Board's statement) to prepare a plan for a field study, but should instead write the Secretary of State." (Letter from Dael Wolfle to R. A. Carpenter, July 10, 1969, op. cit.)

[114] Membership in June 1969, consisted of: Dr. Jack P. Ruina (Chairman), Vice President for Special Laboratories, Massachusetts Institute of Technology; Dr. David A. Berkowitz (Executive Secretary, Sub-Department Head, The MITRE Corporation; Dr. Theodore C. Byerly, Administrator, Cooperative State Research Service, U.S. Department of Agriculture; Dr. John E. Cantlon, Professor of Ecology, Michigan State University; Mr. William M. Capron, Senior Fellow, Brookings Institution; Dr. Barry Commoner, Professor of Biology, Washington University; Dr. H. Jack Geiger, Professor of Preventive Medicine, Tufts University School of Medicine; Dr. Jacob E. Goldman, Vice President, Research and Development, Xerox Corporation; Dr. Oscar Harkavy, The Ford Foundation; Dr. William T. Kubisch, AAAS Staff Representative; Dr. Walter Modell, Professor of Pharmacology, Cornell University College of Medicine; Dr. Arthur M. Squires, Professor of Chemical Engineering, City College of the City University of New York; Dr. Dael Wolfle (ex officio), AAAS.

There was available no indication that its future program would lude the design [redacted] ecological survey of herbicide effects in Viet-, or even the de[redacted]ment of criteria that such a survey would need satisfy. It remain[redacted] to be seen whether its membership could pre-e both stability of leadership and forward momentum.

n comment on the status of the AAAS action on postwar examina-n of the consequences of herbicides use in Vietnam, Dael Wolfle has plained that at the board meeting in April 1969, there had been no ly to the letter from Dr. Roberts to the Secretary of State, but the ard chose to wait a little longer. The State Department still had not lied by the time of the June meeting, so the board felt it necessary to rn to its December 1968 statement. Accordingly, the AAAS board, hat time, began organizing a meeting of representatives of national l international scientific organizations to begin planning the recom-nded field study. Dr. Wolfle noted that both the State Department l the Office of Defense Research and Engineering were on record as proving the idea of a substantial field study. He expressed the hope t the proposed AAAS sponsored meeting would get this study der way.[115]

Pfeiffer's Volunteer Herbicide Assessment Expedition

The originator of the motion that had involved the AAAS in the bicide controversy, Prof. E. W. Pfeiffer, of the University of ntana, had persistently called, throughout subsequent developments, an objective, authoritative, on-the-spot examination and analysis the ecological impacts of repeated application of herbicides mili-y purposes. He had been frequently quoted with reference to the vious attempts at assessment. The MRI study was a "snow job"; Saigon assessment too general. In October 1968, he still sought a l study:

> here there's a will there's probably a way [he was quoted as saying]. I can-believe that there is that much fighting going on in the areas affected by bicides. Some things could be learned and some knowledge is better than no wledge, which is our situation now. Simply from conversations with South namese biologists and French plantation owners on the scene, valuable infor-ion could be obtained * * *. Already, some European scientists have been, North Vietnam, into the battle zones and have pictures of defoliation ts."[116]

The AAAS resolution in December 1968, calling for a "field study the potential long- and short-term ecological risks and benefits of bicide use" was attributed "to the dogged persistence of AAAS mbers such as Pfeiffer and of some members of the board." [117] Pfeiffer had also been active, during 1968, in attempting to arouse erest in having a survey organized under the sponsorship of the iety for Social Responsibility in Science (SSRS). In this effort was supported by Franklin Miller, Jr., of Kenyon College, Gambier, o, and vice president of the society. Miller was reported as saying: hen the war ends it will be of the utmost importance to restore the ductivity of the land areas in the combat zones. It is an urgent task

[115] Letter from Dr. Dael Wolfle to R. A. Carpenter, July 10, 1969. Op. cit.
[116] "It's still 'no' on AAAS efforts to launch Vietnam ecological survey," op. cit., p. 19. Bryce Nelson, "Herbicides in Vietnam: AAAS Board Seeks Field Study," op. cit., p. 58.

to gather the necessary information as a basis for sensible and prompt [redacted]tion." Accordingly, his group was "* * * * seeking ways i[redacted] revive interest in such an investigation." [118] Even before t[redacted]AS meeting in December 1968, Dr. Pfeiffer had announced his [redacted]ion of conducting a reconnaissance survey in Vietnam under the auspices of the SSRS. According to a statement in the newsletter of the society, "the trip should produce valuable information and may serve as a pilot project for a much larger investigation into this field long overdue for scientifically trained observation." The plan for the survey was described as follows:

> I. PURPOSES
>
> (*a*) To stimulate awareness among scientists of the need for an intensive and long-term study of the effects of military uses of chemical agents in Vietnam.
> (*b*) To demonstrate the possibility of obtaining meaningful information even with limited funds and personnel.
> (*c*) To obtain from Vietnamese scientists information related to the military uses of chemicals in Vietnam.
> (*d*) To obtain samples of soil, water, plant, and animal tissues from treated areas for analyses to determine levels of contamination by different chemicals.
> (*e*) To determine effects of defoliants and herbicides on animal populations.
> (*f*) To make a cinematographic record of areas in Vietnam that have been treated by defoliants and herbicides.
>
> II. METHODS
>
> (*a*) Interviews with Vietnamese scientists and officials of such organizations as the National Committee for the Conservation of Nature in Vietnam.
> (*b*) Examine hospital records with reference to patients suffering from exposure to war gases.
> (*c*) Collect samples of soil, water, plant, and animal tissues from areas exposed to chemicals. Analyze these samples, at laboratories in the United States to determine concentrations of chemicals.
> (*d*) Estimate population of different mammalian species in chemically treated areas and in ecological similar areas not treated by chemicals. Use standard small mammal or bird population sampling techniques.
> (*e*) Make 16 millimeter motion picture records of the areas in Vietnam that have been treated with chemicals."[119]

It was not evident that this ambitious plan of investigation was feasible in a 15-day incursion into a region of actual combat, by two zoologists, one specializing in the evolution of vertebrate social systems and the other interested mainly in the renal physiology of mammals. Even with the assistance of the Department of Defense, which enabled the two scientists to fly defoliation missions, inspect defoliated areas from gunboat and helicopter, and converse with biologists in Saigon, their findings were necessarily largely based on qualitative information and hearsay. Much of it was economic information about damage being claimed by managers of rubber plantations.

Professor Pfeiffer, accompanied by Prof. G. H. Orians, of the department of zoology, University of Washington, Seattle, visited the Republic of Vietnam, from March 17 to April 1, 1969, pursuant to this plan. They flew defoliation missions, and observed the effects

[118] "Chemical survey in Vietnam planned by university and industry scientists," Scientific Research, Aug. 5, 1968, p. 15.
[119] SSRS Newsletter, No. 194, November–December 1968, p. 1.

f defoliation by air and by river patrol boat in the Mekong Delta. In a preliminary report, April 3, they noted:

> Crop d[redacted]on programs had been reduced to about one-third of 1967 level;
>
> Defoliation of protective cover was being maintained at about its 1967–68 level:
>
> Agent white (picloram and 2,4-D) was being used much more extensively in the central highland than previously, because of its low volatility;
>
> Bird life in the "Saigon River Delta" had apparently been greatly reduced;
>
> No adverse effect from toxicity against mammals was noted from agent blue (cacodylic acid);
>
> Accidental defoliation "had been very costly, and is a factor in the greatly reduced rubber production in Vietnam:"
>
> "We determined from conversations with U.S. AID experts that the defoliation program is a potential threat to the forest industry of South Vietnam" such that multiple applications "may kill approximately 50 percent of commercially valuable timber in defoliated forests."
>
> "* * * A great deal of accidental defoliation of fruit trees and vegetable gardens has occurred as the result of drifting of defoliant and from jettisoning entire loads of defoliant because of aircraft engine failure;"
>
> The peculiarity of a guerrilla war, without battle lines or secure territory and fixed military targets, inherently results in an effort to increase fatalities, deny resources, and deprive cover to the adversary, which is destructive of lives and ecological communities.[120]

In the press interview in New York upon his return, Professor Pfeiffer expanded somewhat on this report. He observed that it was "completely unrealistic" to expect military commanders to abstain from defoliation actions. "There is no question about it," he said. "They save American lives." On a 65-mile journey by armed boat from Saigon to the sea, he said, "We scarcely saw a living plant." However, he added that had the vegetation not been destroyed, he and his companion would probably not have returned alive."[121]

[120] W. Pfeiffer and G. H. Orians, "The Ecological Effects of the Vietnam War: A Preliminary Report." (Society for Social Responsibility in Science, mimeo, Apr. 3, 1969).

[121] Walter Sullivan, "Zoologist, Back From Vietnam, Notes Defoliants' Value and Toll," *New York Times* (Apr. 4, 1969), p. 5.

V. CONCLUSIONS AND OBSERVATIONS

Initial development of herbicides had been quickly r[redacted]zed in the United States, after World War II, as having enor[redacted]favorable consequences for agriculture. Although their development had been hastened as a part of the scientific effort supporting the war efforts, and a number of new chemicals of unprecedented potency as herbicides resulted from this wartime program, herbicides had long been used commercially in the United States. The rapid adoption of the new chemicals into agricultural practice as weed killers was facilitated by the highly technological character of U.S. agriculture generally. Chemically defoliants were closely compatible with farm practice and yielded important economic gains through increased farm productivity.

Reassessment of the complex secondary and long range consequences of widespread usage of commercial herbicides was intensified after 1962, when the Carson book, "Silent Spring," dramatized the possibly adverse effects of pesticide usage. As more information was accumulated about desirable and undesirable effects of the new chemicals, the initial emotional response stimulated by the book was tempered by a more objective realization that herbicides were both potentially dangerous to the environment and important for human survival. It became evident that active programs of scientific research were essential to discover as much as possible about the "ecosystem" and the effects of pesticides upon it. Only by this effort would it be possible to maximize the benefits and reduce the injurious consequences of the new potent agricultural chemicals. It also became evident that the science of ecology was in its infancy, that an interdisciplinary approach was needed, and that the various disciplines contributing to an understanding of environmental factors were encountering difficulty in exchanging knowledge across disciplinary boundaries.

The initial decision to use herbicides in Vietnam was made by the President of the United States at the request of the Republic of Vietnam. Development of the program took place concurrently with an enlargement of U.S. participation in the conflict. The program was dictated by military advantage. Its primary purpose was to maintain road and canal traffic with a minimum expenditure of lives and manpower. Its undoubted effectiveness for this purpose has motivated its continuation. The program was initiated despite early warnings that adverse public opinion could be expected in response to such a new military application of chemical technology. A positive effort has been maintained by the military services, in cooperation with Republic of Vietnam and United States civil authorities in Saigon and in the field, to counteract the adverse public reaction by the careful screening of targets, restraint in the use of herbicide chemicals, arrangements to reimburse victims of inadvertent damage, and final approval of each proposed application at the highest available levels. The research emphasis in the initial stages of the program was on the development of herbicides that would be effective against the kinds of flora actually encountered in Vietnam. Emphasis was also placed on the achievement of the speediest possible response—the swift defoliation of the jungle after the application of a herbicide. However, atten-

tion was also given to the technology of application to minimize inadvertent spraying of unintended targets and to assure that sprays could be directed efficiently against their intended objectives, with least waste. Throughout the program, the question of toxicity of the chemicals to man and animals was an important concern. Toxicity is important because of the implications for "chemical warfare" and the claims of the Vietcong that many persons had been poisoned by aerially sprayed herbicides. Although toxicity has always been difficult to characterize or measure with absolute precision, and particularly with respect to long range effects of repeated exposures, there has been much experience in the United States with the measurement of herbicide toxicity for practical purposes of home and farm use.

Assessment of the use of herbicides in Vietnam has proved more complex and difficult than the assessment of the use of these same materials in the United States. One important complicating factor is the controversial nature of U.S. participation in the hostilities. Another is the question as to the propriety of chemicals as a part of the technology employed in conflict—the possible escalation that might result from it, and the general desirability of preserving thresholds to such escalation. A third complicating factor is the informal and limited nature of the conflict itself: (1) a number of nations are giving support to the Republic of Vietnam, and a number of other nations are giving support to the guerrillas and the organized forces of the North Vietnamese; (2) specific restraints have been decided upon and declared in effect in the conduct of the hostilities; (3) a large part of the hostilities are conducted within the jurisdictional limits, if not control, of the Republic of Vietnam; (4) a very large part of the use of herbicides, along transportation arteries, has both military advantage to reduce the likelihood of ambush and the same general convenience that motivates its use along right-of-way in the United States.

A fourth complicating factor is the imposition of the restraints of military security over the flow of information about various aspects of the conflict, including the use and the effects of herbicides.

A series of protests arose among scientists in the United States as the herbicide program in Vietnam expanded after 1962. The general rationale for protests from this source was that since scientists had contributed to the development of the new technology of herbicides, they had a right to exercise some extent of moral or technical assessment of their use.

It is indeterminate as to the extent that this anxiety to assess was intensified by the disapproval of U.S. participation in the conflict. However, the fact that annual spraying of herbicides in the United States, since 1965, has maintained a level of some 120 million acres suggests that the greater concern over the more intensive use of similar herbicides against 5 million acres in Vietnam is motivated in part by considerations beyond that for ecological consequences.

A long array of specific issues has been raised as questions associated with military herbicide usage: toxicity to man and animals, synergistic toxicity of several herbicides in combination, or in combination with other environmental factors, or in interaction with the soil, or other chemical compounds resulting from decomposition; concentration of herbicides along food chains, in surface water, in underground reservoirs, in water plants or organisms, in groundwater, or in the soil; effects of herbicides on timber crop and rubber production, or on food supply generally; losses of domesticated and wild animals, fish and birds; threatened extinction of rare species; genetic impairments of animals or plants; encroachment of unwanted species on bared areas; mass destruction of sensitive vegetation (e.g., mangrove) requiring decades to recover; and possibility of laterization of exposed jungle soils.

In an effort to distinguish military from civilian use of herbicides attention was drawn to the asserted greater intensity and more frequent application of defoliants to achieve military objectives, the moral issue of crop destruction, and the question as to the propriety of using chemicals to expose enemy personnel to attack by conventional weapons. The question was also raised as to the military ability to exercise due restraint in the type, amount, and frequency of herbicide applications.

The annual meetings of the American Association for the Advancement of Science provided an opportunity for the scientific politicization of the issue. Once the council of the AAAS had adopted a resolution bearing somewhat on the relationship of herbicides to the human environment, those concerned with the use of herbicides in Vietnam continued to keep the question of this war use alive among the membership and the leadership of the association. An attempt was made to separate the thorny political question of military herbicides from the broader but less inflammatory technical issue of "environmental alteration." However, when the board of directors of AAAS attempted to develop a position on the military herbicide issue, it was able to agree substantially on only the one proposition that the long-range ecological effects needed study.[12] However, the board of directors did not speak with a single voice, but with five. The effect of its diffused expression of views was doubtful. All parties were agreed as to the desirability of learning more about the long-range ecological effects of intensive military use of herbicides. But the AAAS board of directors had not assumed leadership in defining what form this assessment should take. By June 1969, neither those who favored nor those who opposed defoliants in Vietnam had given a clear indication as to what the ecological questions were nor how they should be answered.

A number of observations can be made on the record of this assessment process. One is that a large federation of scientific societies like the AAAS can provide a valuable forum in which to discuss issues of great public moment. The annual meetings of the AAAS bring together from all over the United States scientific specialists from many disciplines. An opportunity is provided for those in each individual discipline to exchange knowledge, and also for the valuable cross-fertilization of interdisciplinary discussions. Issues that rise out of this intellectual ferment, and become recognized by a substantial part of the membership present at these meetings as important concerns,

[12] To be sure, it was also somewhat concerned about the use of cacodylic acid, and urged that its use be "suspended" until more was known about its "fate." But in Saigon, two months later, Dr. Minarik characterized as trivial the quantities of products of doubtful toxicity that were left on the ground from the use of this chemical. The same judgment was offered in AAAS discussions the following December by Dr. Day.

deserve to be taken seriously by the public at large. With the effective—if sometimes imprecise—aid of the public press, the AAAS is able to identify and characterize scientific issues in which the general public has a legitimate concern.

By the same token, the AAAS board of directors in its more frequent meetings, and the AAAS Council in its formal annual assemblies, are able to crystallize these issues in a form that can be communicated to responsible political decisionmakers. Board actions and council resolutions can serve usefully as challenges to existing policy, and as demands for policy reviews. Sometimes, the need for specific actions or changes can even be made apparent. In the herbicide case, this combination of organizational forces gave undoubted emphasis to the efforts of the Department of Defense to keep its own house in order, and to anticipate the need for information about its program. Military reassessment might have gone on in any event, but the persistent expressions of concern from the governing bodies of the AAAS may have helped to make these reassessments more frequent and more searching.

Another observation is that any issue on which there are both difficult scientific questions and intense political feeling is unlikely to be resolved in the great forum of discussion that the annual meetings of the AAAS produces. Even the more formal and structured sessions of that AAAS Council appear to be an inappropriate mechanism for the resolving of such political/scientific issues. And, indeed, the relatively small and select group that comprises the "legal entity" of the AAAS is not effective as an instrument for technology assessment.

The question might be asked as to whether, indeed, the AAAS or any of its component parts should be expected to function as a decision-making body on technological assessment matters with a substantial political content. Can scientists, any more than other people, compartmentalize their judgment regarding issues they feel strongly about? Can they ignore the political content and address themselves in pure fashion to the technical?

The history of the herbicide controversy illustrates once more the inherent difficulty of demonstrating a negative scientifically. Questions relative to acute toxicity and ecological effects of herbicides used in Vietnam were answered for immediate practical purposes. However, definitive answers as to chronic long-term toxicity, genetic impairment, and long-term ecological consequences were not available relative to Vietnam any more than they were for the United States.

It can probably be concluded with justice that the herbicide question—military or civilian—is a part of the larger question of ecological and environmental consequences of and for man. Apart from the ethical or normative issues of the Vietnamese war, the question of the consequences of herbicide use on the environment is a serious and difficult one, but one that needs to be answered. The means by which to provide the answers are not yet at hand. The fact that all parties involved in the assessment have agreed to look long and hard at the post-war Vietnamese ecology is reassuring. However, the state of the art of the ecological disciplines, and the ability of professional people in these disciplines to exchange knowledge and understanding, will be tested to the limit in the performance of such an assessment.

If upon this labor is superimposed the added burden of judging ecological questions in a context of political and moral dispute, the task is perhaps insuperable. It is possible that the study of the ecological effects of herbicides might be more rewarding for the general purposes of science and public policy if conducted in areas selected to maximize the informational values, and to minimize the extraneous variables, instead of in Vietnam where the use of herbicides was dictated by military expedience—irrelevant to the purposes of science—and where the results would be likely to be clouded by emotional dissonance.

66

APPENDIX A

Draft of Pending Section of Manual on Use of Herbicides for Military Purposes

MS Supplied by Department of the Army

Section I. Technical Aspects

51. General

Antiplant agents are chemical agents which possess a high offensive potential for destroying or seriously limiting the production of food and defoliating vegetation. These compounds include herbicides that kill or inhibit the growth of plants; plant growth regulators that either regulate or inhibit plant growth, sometimes causing plant death; desiccants that dry up plant foliage; and soil sterilants that prevent or inhibit the growth of vegetation by action with the soil. Military applications for antiplant agents are based on denying the enemy food and concealment.

52. Antiplant agents in use

a. ORANGE.

(1) *Description.* Agent ORANGE is the Standard A agent. It is composed of a 50:50 mixture of the n-butyl esters of 2,4-D and 2,4,5-T (app D and C1, TM 3-215). ORANGE appears as a dark-brown oily liquid which is insoluble in water but miscible in oils such as diesel fuel. It weighs about 10.75 pounds per gallon and becomes quite viscous as the temperature drops, solidifying at 45° F. It is noncorrosive, of low volatility, and nonexplosive, but deteriorates rubber.

(2) *Rate of application.* The recommended rate of application of ORANGE is 3 gallons per acre. This may vary depending on the type of vegetation (app C). In some situations better coverage may be obtained by diluting ORANGE with diesel fuel oil, which results in a less viscous solution that is dispersed in smaller droplets. Dilution may also be required when using dispersion equipment which does not permit the flow rate to be conveniently adjusted to 3 gallons per acre. See discussion of application methods in paragraphs 57 and 58.

(3) *Effect on foliage.* ORANGE penetrates the waxy covering of leaves and is absorbed into the plant system. It affects the growing points of the plant, resulting in its death. Rains occurring within the first hour after spraying will not reduce the effectiveness of ORANGE to the extent that they reduce the effectiveness of aqueous solutions. Broadleaf plants are highly susceptible to ORANGE. Some grasses can be controlled but require a much higher dose rate than broadleaf plants. Susceptible plants exhibit varying degrees of susceptibility to ORANGE. Death of a given plant may occur within a week or less, or may require up to several months depending on the

plant's age, stage of growth, susceptibility, and the dose rate. See employment considerations in paragraphs 53 through 55.

(4) *Safety precautions and decontamination.* ORANGE is relatively nontoxic to man or animals. No injuries have been reported to personnel exposed to aircraft spray. Personnel subject to splashes from handling the agent need not be alarmed, but should shower and change clothes at a convenient opportunity. ORANGE is noncorrosive to metals but will remove aircraft paint and walkway coatings. Contaminated aircraft should be washed with soapy water to remove the agent. Rubber hoses and other rubber parts of transfer and dissemination equipment will deteriorate and require replacement, since ORANGE softens rubber.

b. BLUE (Phytar 560G).

(1) *Description.* Agent BLUE is an aqueous solution containing about 3 pounds per gallon of the sodium salt of cacodylic acid, the proper amount of surfactant (a substance which increases the effectiveness of the solution), and a neutralizer to prevent corrosion of metal spray apparatus. BLUE is the agent normally used for crop destruction.

(2) *Rate of application.* BLUE may be sprayed as received from the manufacturer without dilution, if desired. The recommended application rate for crop destruction is about 1 to 2 gallons per acre (app C). However, much higher use rates of BLUE are required to kill tall grasses, such as elephant grass or sugarcane, because of the large masses of vegetation. For hand-spray operations, two gallons of BLUE diluted with water to make 50 gallons will give a solution that can be dispersed by hand at a rate equivalent to approximately 1 to 3 gallons of pure agent per acre.

(3) *Effect on foliage.* Enough BLUE applied to any kind of foliage will cause it to dry and shrivel, but the agent is more effective against grassy plants than broadleaf varieties. Best results are obtained when the plant is thoroughly covered, since the agent kills by absorption of moisture from the leaves. The plants will die within 2 to 4 days or less and can then be burned if permitted to dry sufficiently. Blue in low dose rates can also prevent grain formation in rice without any apparent external effect. The plant develops normally but does not yield a crop. Spray rates higher than about one-half gallon per acre usually kill the crop. Although BLUE can produce relatively rapid defoliation, regrowth may occur again in about 30 days. Repeated spraying is necessary to provide a high degree of continuous plant kill.

(4) *Safety precautions and decontamination.* Normal sanitary precautions should be followed when handling BLUE. Although it contains a form of arsenic, BLUE is relatively nontoxic. It should not be taken internally, however. Any material that get on the hands, face, or other parts of the body should be washed off at the first opportunity. Clothes that became wet with a solution of BLUE should be changed. Aircraft used for spraying this solution should be washed well afterward. When WHITE is added to BLUE, a precipitate forms that will clog the system. If the same spray apparatus is to be used for spraying agents WHITE and BLUE, the system must be flushed to assure that all residue of the previous agent is removed.

c. WHITE (Tordon 101).

(1) *Description.* The active ingredients of agent WHITE are 20 percent picloram and 80 percent isopropylamine salt of 2,4-D. Active ingredients constitute about 25 percent of the solution. A surfactant is also present. WHITE is soluble in water, noncorrosive, nonflammable, nonvolatile, immiscible in oils, and more viscous than ORANGE at the same temperature.

(2) *Rate of application.* WHITE usually should be applied at a rate of 3 to 5 gallons per acre on broadleaf vegetation. However, the rate may vary depending on the type of flora. Quantities required to control jungle vegetation may vary from 5 to 12 gallons per acre. This quantity exceeds the spray capability of most aircraft spray systems for a single pass. It is usually unfeasible in large-scale military operations to apply such large volumes. For ground-based spray operations, however, high volumes are necessary. Hand-spray operations cannot evenly cover a whole acre with only 3 gallons of solution. Three gallons of WHITE diluted to a 30-gallon solution can be more easily sprayed over an area of one acre. The manufacturer recommends diluting WHITE with sufficient water to make a 10-gallon solution for each gallon of agent.

(3) *Effect on foliage.* WHITE kills foliage in the same manner as ORANGE, since 80 percent of the active ingredient is 2,4–D. PICLORAM is more effective than 2,4–D, but acts slower. WHITE is effective on many plant species, and equal to or more effective than ORANGE on the more woody species. The material must be absorbed through the leaves. The water solution does not penetrate the waxy covering of leaves as well as oily mixtures, and is more easily washed off by rain.

(4) *Safety precautions and decontamination.* WHITE exhibits a low hazard from accidental ingestion. However, it may cause some irritation if splashed into the eyes. Should eye contact occur, flush with plenty of water. Splashes on the skin should be thoroughly washed with soap and water at the first opportunity. Contaminated clothing should be washed before reuse. When WHITE is used in the same equipment as BLUE, all of the WHITE should be removed before using BLUE. The two agents produce a white precipitate that will clog spray systems.

d. Soil Sterilants.

(1) *BROMACIL.*

(*a*) *Description.* BROMACIL is an odorless, noncorrosive, white crystalline solid, slightly soluble in water or diesel fuel oil. Three different forms are produced: HYVAR-X, a wettable powder containing 80-percent active ingredient; HYVAR-X-WS, a 50-percent active ingredient water-soluble powder; and UROX 'B', a liquid containing 4 pounds of active ingredient per gallon (app D).

(*b*) *Rate of application.* HYVAR-X is applied at a rate of 15 to 30 pounds per acre; HYVAR-X-WS, 24 to 48 pounds per acre; and UROX 'B', 3 to 6 gallons per acre. Spray concentrations of the agent as high as 50 to 150 pounds per 100 gallons of water or oil can be handled by aircraft-mounted spray systems. The 80-percent wet-

(*a*) *Description.* UROX 22 is a granular substance containing 22 percent monuron trichloroacetate.

(*b*) *Rate of application.* The manufacturer suggests using 150 to 200 pounds per acre.

(3) *Effect on foliage.* Soil sterilants act by absorption through the root system and therefore are most effective under conditions of good soil moisture. They are relatively stable once absorbed into the soil. Soil sterilants kill vegetation and may prevent regrowth for periods of a few months to a year, depending on the quantity and soil conditions. They are most effective on grasses, but will control woody plants at higher application rates. Mechanical clearing by brush cutters or bulldozers is not necessary, but will help in getting the agent into the soil.

(4) *Safety precautions and handling.* Soil sterilants are only slightly corrosive to metals, but dispersion equipment should be thoroughly flushed after use. They are relatively nontoxic to humans, but respirator masks should be worn to prevent inhalation of dust during handling.

SECTION II. CONCEPTS OF EMPLOYMENT

53. General

a. The employment of antiplant agents must be carefully controlled by technically qualified personnel to avoid many undesirable aftereffects. FM 3–10 discusses the employment concepts, analysis of operations, and limitations of antiplant agents.

b. Guerrilla operations rely heavily on locally produced crops for their food supply. Crop destruction can reduce the food supply and seriously affect the guerrilla's survival. Naturally dense vegetation in jungle areas is ideal for elusive hit-and-run tactics of the guerrilla. Removal or reduction of this concealment limits the guerrilla's capability to operate in the defoliated area.

54. Employment considerations

In addition to the concepts discussed in FM 3–10, the following points should be considered when planning the use of antiplant agents.

a. Type of Foliage. ORANGE is a wide-range, general-purpose agent which is effective on the many types of foliage found in jungle areas. WHITE is also considered a general-purpose herbicide, but it is generally slower than ORANGE. BLUE is most effective on the narrow leaf species: the grasses, sugarcane, rice, and other cereal grains.

b. When to Apply. The best time to apply antiplant agents is during the most active growing season. This corresponds roughly to the period [illegible] the appearance of new buds until 3 or 4 weeks before onset of [illegible] season. While spraying during the dry season does produce [illegible]ation, vegetation is not killed as quickly as it is during the most active growing season. An exception would be in certain tropical lowland areas where water is plentiful and continuous growth exists; thus antiplant agents are effective throughout the year.

a. In some plants, leaves and growing stems form [illegible] and coils or develop marked curvature.

b. Growing stems may remain green, but may swell, develop cracks, and form callous tissue.

c. Watery, translucent buds often appear at the crowns of some plants.

d. Spongy, enlarged roots may appear, turn black or gray, and rot.

e. Dead areas will form on the leaves wherever the spray droplets have settled on the leaf surface. A yellow ring may appear around the dead area, and gradually the entire leaf will develop yellow, brown, or red autumnal coloration and fall.

SECTION III. DISSEMINATION METHODS

56. General

Antiplant agents may be disseminated by various methods depending on the size of the area to be defoliated and whether the agent is in liquid, slurry, or solid form.

57. Ground-based application

Ground-based spray or dispersion methods are suited to small-scale operations such as defoliation around base camps or installations or clearing along routes of communication. These methods depend on easy access to the area on foot or by spray vehicle.

a. Hand broadcasting is the simplest way to disperse dry agents, such as soil sterilants, but is a rather time-consuming method.

b. A 3-gallon hand-pump sprayer is easy to use in areas accessible by foot but where vehicles cannot enter. It is a slow method, however, and areas out of arm's reach are still inaccessible.

(1) *UH–1 series aircraft.*

(*a*) A simple expedient spray system for a UH–1 type aircraft might consist of a 55-gallon drum fitted with a rubber hose which delivers the solution to a spray bar temporarily mounted across the skids. Slight pressurization of the drum will usually help empty the drum at a steady rate. A portable flamethrower pressure bottle or an AN–M4 compressor can be used for pressurizing, but a gage should be in the system to warn of excess pressure (no more than 8 to 12 psi should be used). The size and number of holes in the spray bar may be determined by trial and error; however, ⅛-inch holes spaced 6 inches apart will provide good results.

(*b*) Another field expedient system uses the tank and 16-foot boom of the HIDAL. A 25-gpm personnel carrier bilge pump delivers the agent, allowing 30 to 40 meters coverage in width.

(2) *CH–47 aircraft.* An expedient spray system for a CH–47 aircraft might consist of a 500-gallon collapsible fuel bladder or a 400-gallon metal, skid-mounted tank. A power-driven fuel transfer pump (50 to 100 gpm) can be used to deliver the antiplant agent to a spray bar attached to the ramp at the rear of the aircraft.

. The M106 Mity Mite (para 26) may be used to disperse liquid or ry antiplant agents. Foot access to the area is required, but inaccessible areas may be covered to some extent, since the Mity Mite will spray a distance of about 50 feet.

d. A power-driven decontaminating apparatus (PDDA) may be used when the area is accessible to wheeled vehicles. It is especially suited for spraying soil sterilant in slurry form. The PDDA may also be used to spray liquid antiplant agents. WHITE and BLUE present no corrosion problems, but the apparatus must be well cleaned when changing between the two agents. ORANGE will soften the rubber parts, such as hoses and valve diaphragms, requiring their replacement after a while. Spraying ORANGE by PDDA also produces a fire hazard.

c. Commercial orchard sprayers, if available, may be used for spraying liquid solutions where ground access to vehicles is possible.

5. Aerial spray methods

Aerial spray methods are suited for large-scale operations, since a larger area can be covered and ground access is not necessary. Aerial application methods are much more subject to weather conditions, such as wind direction and speed and temperature gradient, than are ground-based methods. Therefore, particular attention must be paid to the possibility of agent drift onto any nearby friendly crops. The height of attack, airspeed, and area coverage depend on weather and terrain conditions and pilot experience.

a. UC–123B Aircraft. UC–123B cargo aircraft fitted with internal tanks and external spray booms are used for large-scale defoliation and crop destruction operations. Using the present systems at an altitude of 150 feet and airspeed of 130 knots results in a spray rate of 3 gallons per acre.

b. FIDAL (Fixed-wing Insecticide Dispersal Apparatus, Liquid). The FIDAL is a Navy developed and tested system. It has not been standardized by the Army. When available, it can be used to supplement the spray capability of the C–123 systems. The FIDAL is hung on the AIE or AIH aircraft without modification. Each tank holds about 275 gallons and has its own ram air turbine to provide power for pumping the spray through a spray boom. Cost is much less than that of C–123 inboard systems, and spray missions do not tie up the aircraft since the tanks can be hung or removed in minutes.

c. Helicopter-Mounted Spray Systems.

(1) *HIDAL (Helicopter Insecticide Dispersal Apparatus, Liquid).* The HIDAL system is a 196-gallon spray system suitable for use in a UH–1 series helicopter. Helicopters are useful in spraying areas around installations that are not accessible to wheeled vehicles: minefields, barbed wire barriers, etc. The HIDAL is self-contained, has an adjustable spray rate, and can be installed and removed in a matter of minutes. It is a Navy developed system and has not been standardized by the Army.

(2) *AGAVENCO sprayer.* The AGAVENCO system has capabilities similar to those of the HIDAL and is presently being procured in a limited quantity. It has not been standardized.

d. Field Expedient Spray Systems. When systems such as the HIDAL are unavailable, field expedient spray systems that will perform adequately might be constructed.

e. Effect on Nearby Crops. If the application of antiplant agents is on target to begin with, the main danger to nearby susceptible crops will be from drift. The main factors affecting agent drift are wind direction and speed, dissemination method (para 56 through 58), temperature gradient (TM 3–240), and the agent used. Conditions for dissemination of antiplant agents are usually most favorable during early morning hours (before 0800) while inversion temperature gradient prevails and the wind speed is still low (does not exceed 8 knots). A volatile antiplant agent may also produce drift effect even after the spray has settled on target. For example, the slight vaporization of ORANGE may produce drift damage, especially if nearby crops, such as rubber trees, cotton, melons, bananas, and other garden species, are *highly* susceptible to damage. Water-soluble agents BLUE and WHITE are not subject to vaporization after settling on target. Thus they can be more safely used near susceptible crops provided cautions such as wind direction are heeded, and a dissemination method that tends to produce the least amount of drift is used. Although soil sterilants do not drift, they should not be used closer than 100 meters to crops or cropland in a friendly area onto which drainage from treated areas flows.

d. Duration of Effect. Neither ORANGE, BLUE, nor WHITE can be considered "permanent" type antiplant agents. They act by direct contact with the plant. Defoliation resulting from aerial application of BLUE may be effective only until new growth appears. Defoliation resulting from aerial application of ORANGE or WHITE will usually be effective for one growing season, but may be effective for periods of approximately 9 months to 1 year. Soil sterilants, on the other hand, may be effective for periods of up to a year or more, because they are designed to be slowly dissolved by rainfall and remain active in the soil.