that are so poorly understood raises serious moral and political questions for the U.S. government and for the American people. These ought to be carefully considered in the present national debate on the morality and political wisdom of the war in Vietnam.

BARRY COMMONER, GERALD HOLTON
H. BURR STEINBACH

2) We consider 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. We consider that the material in the Midwest Research Institute report in general supports this view.—WALTER ORR ROBERTS, KENNETH V. THIMANN

3) We do not agree that the Board of Directors should recommend that the United Nations assume responsibility directly for making the proposed study. While we would agree that the U.S. government should propose that the United Nations sponsor the study, we believe 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.

H. BENTLEY GLASS
HUDSON HOAGLAND, GERALD HOLTON
PAUL E. KLOPSTEG, DON K. PRICE
MINA S. REES, LEONARD M. RIESER
WALTER ORR ROBERTS
H. BURR STEINBACH, DAEL WOLFLE

Herbicides in the Perspectives of 20 Months and 20 Years

The wartime plutonium production project had a fantastic safety record. So does the ever-expanding U.S. peacetime power reactor program. Neither came about by accident. There was concern at the top. It was reflected in the concerned collaboration of competent colleagues. Their experience stretched from the safe manufacture of ammonia under unprecedentedly high pressure to the safe manufacture of high explosives, from biology to meteorology, and from safety against sabotage to sanitary engineering. I am a nuclear physicist. I was privileged to work with these able men from 1942 to 1953. In addition to other responsibilities I had this double duty: First, to dream up every conceivable way in which trouble might come about, however fantastic; and second, to make order-of-magnitude calculations of the size of the effect to be expected—and of the means to protect against it. Out of this personal experience* come three working principles relevant to the use of herbicides:

First, every significant pathway by which a contaminant—or a perturbation—can make its way from A to B must be part of the bookkeeping before one can chalk up the final safety balance. Second, one need not know the flow in every pathway to have the information needed for safe action. Instead it is enough to consider for each imaginable situation the "worst case," make the appropriate order-of-magnitude calculation, and take safety measures accordingly ("upper limits" versus "actual values"; "margin of safety" approach). Third, as subsequent research reveals more about individual pathways, safety margins undergo further improvement, or economy of operation rises, or both.

From going through the Midwest Research Institute Report and the careful reviews of that report by the National Academy Committee and others qualified in the field, and from considerable additional discussions, I am led to conclude that

1) We know enough today to set a variety of useful upper limits.

2) Twenty more months of research will not produce an order-of-magnitude increase in the available information.

3) The information on hand is a guide to policy and can be summarized so succinctly, and—what is more—put into perspective that any final report to AAAS members will be deficient if it does not undertake this task. A few facts and figures may be given as examples, focused on acres, pounds, and pounds per acre (Table 1).

Certain additional elementary items of information and "worst cases" are significant for perspective. For example (a) 2,4-D, long familiar as the leading herbicide and still a leader, is being overtaken by other herbicides which, however, do not have radically different properties. As an addendum to the Board statement implies, the use of herbicides for defoliation is a device of unprecedented harmlessness for saving allied lives. (b) Quite different from 2,4-D is arsenic containing cacodylic acid (dimethyl arsenic acid). For a time it found favor as a leaf remover. Now it is being dropped gradually for the same reason that arsenical sprays are being given up in tobacco land: The arsenic slowly accumulates and in years can become a liability to animal health. For

Table 1.

Area of first 48 states	2000×10^6 acres
Wooded United States	638×10^6 acres
Commercial forest industries	67×10^6 acres
Herbicide-sprayed farmland, United States, 1959	53×10^6 acres
Sprayed farmland, 1965	120×10^6 acres
Rightaway: Power, phones, roads, railroads	26×10^6 acres
Mesquite-affected range in Southwest	70×10^6 acres
Sprayed range in Southwest	3×10^6 acres
Area of Rhode Island	0.8×10^6 acres
D.M.Z. in South Vietnam, 6 miles by 50 miles (sprayed)	0.2×10^6 acres
Cropland in South Vietnam sprayed to deny crops to Viet Cong	About 0.2×10^6 acres
Cultivated land in South Vietnam not so sprayed	8×10^6 acres
S.U.N. forest defoliated per year to permit inspection	About 1×10^6 acres
Total forests of Indo-China	77×10^6 acres
Use of 2,4-D ("Weedone") or 2,4,5-T or mix	
To improve grazing in forest for deer and rabbits	1 lb./acre
To kill undersirable hardwoods, preserve pines	4 lb./acre
To kill brush, save pine seedlings	8 lb./acre
To control knapweed on range	100 lb./acre
To remove leaves for 4 months from jungle canopy	5 to 30 lb./acre
To start conversion of jungle to grazing or cultivatable land	5 to 30 lb./acre
1966 U.S. use of 2,4-D	57×10^6 lb.
U.S. annual production capacity of 2,4-D	80×10^6 lb.
Estimated needs for 2,4-D in Southeast Asia per year	80×10^6 lb.
Total U.S. production of herbicides per year	300×10^6 lb.

* A distinct report because written by a Board Member with a distinct background.

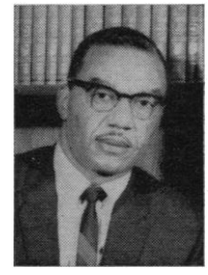
the extreme case of feeding directly on cacodylic acid, 50 percent of animals are lethally affected by 1 to 2 grams per kilogram of body weight. (c) Not a herbicide at all is the familiar *insecticide* DDT (flies, mosquitoes) whose many year life, accumulation in earthworms, and transfer to birds have stirred concern. (d) A rabbit remains healthy eating all day, every-day vegetation freshly sprayed with 2,4-D. (e) This herbicide in surface water is degraded to 1 percent of its original strength in 30 days. Leakage of herbicide from spray planes taking off produces less effect on trees near the Tan Son Nhut Airbase than Saigon smog. (g) Some of the spray from a plane one too-windy day was carried almost 15 miles down wind and killed some rubber trees (damage payments $87 each). (h) The most extreme situation anyone has envisaged in Vietnam is "creation of 800,000 additional refugees" and "wild rats infected with the plague . . . displacing the less dangerous city rodents." Anyone can make his own estimate of upper limit to "herbicide refugees" by looking at the figures for the amount of cropland sprayed and recalling that the population of South Vietnam, city and country together, is 16.5 million.

Fourth, if information now on hand serves as guide to action for the next 20 months, it looks like 20 years to understand in detail the effect of land clearing, whether by old-fashioned brute force or the modern herbicides, on the balance of plant and animal life. For this reason one ecologist rates the operation in Vietnam as "a gigantic and valuable experiment of global proportions." And in the United States on 12 July 1968 President Johnson signed a bill authorizing $10.5 millions more for a study dating from 1958 on the effect of chemicals upon fish and wildlife.

As for action: (1) Dissemination of the information now on hand is the single most important step that can be taken to show anew what the Founding Fathers called "a decent respect for the opinion of mankind." (2) An appropriate United Nations committee can recommend limits on arsenicals and report facts, as another such committee did on radiation dosage and effects of nuclear weapons. However, as in that case, so in this—no such committee can be expected to make field measurements or agree on major policy recommendations. (3) United States-supported research and field tests, the bulk of it in the United States itself, will be the major source of new knowledge. (4) On what goes on in Vietnam, as for peacekeeping operations, so for herbicides, the responsibility lies in the first instance with the local people: (a) The South Vietnam Air Force initiated the use of herbicides. (b) The South Vietnam representatives sit in on the planning and have veto power over every airborne herbicide operation. (c) The herbicide program receives attention in the local press in both South and North Vietnam. (d) There is a group of able French-trained Vietnamese biologists in the Saigon area who are interested in herbicides and are capable of contributing valuable field studies if supplied with a jeep. Many have associations with the National Committee for Nature Preservation in South Vietnam. (e) In the bright economic future recently envisaged for Vietnam by David Lilienthal herbicides will be a decisive factor in augmenting the already great output of food and fiber.—JOHN A. WHEELER

APPOINTMENTS

R. L. Sproull



M. M. Nance

Robert L. Sproull, academic vice president of Cornell University, to provost and vice president of the University of Rochester . . . . **M. Macco Nance,** acting president of South Carolina State College, to president of the college . . . . **Richard L. Masland,** director of the National Institute of Neurological Diseases and Blindness, to professor and chairman of the department of neurology, College of Physicians and Surgeons, Columbia University . . . . **Robert J. Glaser,** vice president for medical affairs and dean of the Stanford University School of Medicine, to acting president of the university . . . . **Ned D. Bayley,** deputy director of science and education in the office of the secretary of the Department of Agriculture, to director of science and education for the department . . . . **Herman B. James,** dean of the school of agriculture and life sciences, North Carolina State University, to assistant administrator for the War on Hunger under the Agency for International Development . . . . **Joseph M. Goldsen,** former head of the social science department, RAND Corporation, to executive director of the Concilium on International Studies and assistant to the provost at Yale University . . . . **John Legaris,** first vice president of the National Air Pollution Control Association, to president of the association . . . . **Mark Ferber,** University of California representative in Washington, D.C., to special assistant to Vice President Charles Hitch as coordinator of the university's new program on urban problems . . . . **Fred S. Honkala,** dean of the University of Montana Graduate School and director of research for the University of Montana Foundation, to a 1-year leave of absence as director of the Advanced Science Education Program for the National Science Foundation . . . . **Lawrence M. Kushner,** acting chief of the Institute for Applied Technology of the National Bureau of Standards, to director of the institute . . . . **Donald R. Chadwick,** director of the National Center for Chronic Disease Control of HEW, to deputy director of the division of Regional Medical Programs . . . . **Pierre R. Demarque**, professor of astronomy at the University of Chicago, to professor of astrophysics and chairman of the department of astronomy, Yale University. . . . **Theodore Cooper**, associate director of the National Heart Institute and chief of its Artificial Heart-Myocardial Infarction Program, to director of the institute. . . . **Ward J. Haas**, director of the Space Sciences Research Center at the University of Missouri, to vice president of Warner-Lambert Pharmaceutical Co. and director of the Warner-Lambert Research Institute. . . . **Martin Cherkasky**, director of Montefiore Hospital and Medical Center, to chairman of the department of community health of the Albert Einstein College of Medicine. . . . **Daniel Banes**, head, division of pharmaceutical sciences in FDA's Bureau of Science, to acting associate commissioner for science.

Erratum. The price of volume 1 of *Venomous Animals and Their Venoms,* reviewed 31 May, Page 984, was given incorrectly. The price of the volume is $34 singly and $28.50 by subscription to the three-volume work.