AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AAAS HERBICIDE ASSESSMENT COMMISSION
BOTANICAL MUSEUM, HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS 02138, U.S.A.

MATTHEW S. MESELSON, CHAIRMAN
ARTHUR H. WESTING, DIRECTOR

12 November 1970

General Creighton Abrams
Commanding General, MACV
Headquarters MACV
APO San Francisco, California 96222

Dear General Abrams,

Following our discussion of September 3 concerning Montagnards and the impact upon them of the chemical crop destruction program, I enclose a copy of a report prepared for Ambassador Bunker.

After only a few weeks in Vietnam we certainly cannot claim to be experts on these questions. Nevertheless I think we were able to come away with an overall perspective that may be broader than can be acquired by operational personnel assigned to highly specific duties.

Some of what is written in the report I told you during our meeting. However in the weeks since our return to the United States we have been able to connect some of the different pieces of information that we had gathered. An example of this which may particularly interest you, as I recall our conversation, is the effect of Montagnard folk tradition as it combines with the effects of the crop destruction program. According to anthropologists, poison occupies a prominent place in the religeous beliefs of many of the highland peoples. They believe that evil spirits live in poison and manifest themselves through its effects. We met refugees from one valley who had sacrificed all their water buffalos, their most prized possessions, before leaving their land, because the animals as well as the valley had become "evil" as a result of the "poison from the sky." Perhaps your son who works among the Montagnards could provide more direct knowledge of how their traditions affect their perception of the use of herbicides.

I very much value the discussion we had, and appreciate your having given me so amply of your time.

With best regards,

Sincerely yours,

Matthew Meselson

Matthew Meselson

MM:em

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15 March 1971

General Creighton Abrams
Commanding General, MACV
Headquarters MACV
APO San Francisco 96222

Dear General Abrams:

I am sending the enclosed Carnegie Endowment study for your possible interest because it contains chapters on the policy questions raised by the military use of riot control agents and herbicides. In the article concerning riot control agents my co-author, Mr. Blumenfeld, and I have attempted to consider the military utility of these weapons as carefully as we can with the rather limited information available. If there should be anyone on your staff who is particularly interested in this matter we would greatly appreciate receiving critical comments.

Last Friday Secretary of State Rogers told the Senate that the crop destruction program in Vietnam has been halted. After our meeting last summer and after the report which we sent to you following that, I am sure I do not need to tell you that, from our point of view, this was a most commendable decision. I consider it a privilege to have had the opportunity to discuss these matters with you while I was in Vietnam.

With warm regards,

Sincerely yours,

Matthew Meselson

Matthew Meselson
Professor of Biology

HARVARD UNIVERSITY
THE BIOLOGICAL LABORATORIES
16 DIVINITY AVENUE
CAMBRIDGE, MASSACHUSETTS 02138

12 August 1971

General Creighton Abrams
Commanding General, MACV
Headquarters MACV
APO San Francisco 96222

Dear General Abrams,

You will recall that on November 12, 1970 I sent to you a copy of a report to Ambassador Bunker on crop destruction in Quang Ngai province. (For your immediate reference, a copy is enclosed.) In response to our report Ambassador Bunker has kindly forwarded to me a memorandum prepared some time ago by someone at MACV. (A copy is enclosed.) I am writing to ask if MACV has conducted any further study or analysis of this subject which could be made available to me.

I am spending most of my time this summer preparing the final report of the AAAS Herbicide Assessment Commission. It will be published as a book sometime next year.

In our final report I want to be as accurate as possible in our discussion of the crop destruction program. In this connection I enclose an exchange of correspondence published in the New York Times. I am also enclosing for your possible interest an article which Dr. Constable and I prepared at the request of the Sierra Club Bulletin. We took the opportunity to express once again our gratitude for the superb assistance we received last August from MACV, the Embassy, and the Government of Vietnam, notwithstanding the rather reluctant attitude of the Department of Defense in Washington.

I hope this letter finds you well.

With kind regards,

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Enclosures:
Report to Ambassador Bunker of November 12, 1970
Article in Sierra Club Bulletin of April 1970
Letters from the New York Times of July 12, 1971 and 4 August 1971
MACV Memorandum

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MATTHEW S. MESELSON, CHAIRMAN
ARTHUR H. WESTING, DIRECTOR

12 November 1970

The Honorable Ellsworth Bunker
American Ambassador
Saigon, Republic of Vietnam
APO San Francisco, California 96243

Dear Ambassador Bunker,

On behalf of the Herbicide Assessment Commission of the American Association for the Advancement of Science, we wish to express our appreciation for the generous assistance provided by the Embassy during our recent tour of the Republic of Vietnam.

We are now preparing our report for presentation to the AAAS at the end of December and will send a copy to you as soon as it is available. Before that time, however, we wish to relay some observations that we believe merit your more immediate attention because they challenge the basis of the current chemical crop destruction program.

On August 21 and 28 we overflew an area in Quang Ngai province where chemical crop destruction operations had been conducted a few days before. The responsible chemical operations staff officer accompanied us on one of the overflights, and we spoke at length with other officers and civilian officials on the scene. It was explained to us that the targets were VC/NVA crop production areas and that most of the food destroyed would otherwise have been consumed by enemy forces. The reasons given for this assessment were that

1. The target area had only a very low population density.

2. The area under cultivation had expanded strikingly in recent years.

3. The cultivated area was much larger than that needed to support the small indigenous population.

4. The existence of numerous terraced rice fields indicated the influx of VC/NVA food production units, since the Montagnards who comprise the native population do not practice terracing.

Our observations are sharply at variance with all four of these points.

Background information. One of the target areas is shown in photograph 1. Three C123 aircraft sprayed herbicide along the Song Re river valley from map coordinates BS 3455 to BS 3543. The photograph was taken near the latter coordinate, looking northward up the valley. The spray swaths are generally visible as brown streaks. Spraying was conducted continuously for a distance of about ten miles, resulting in coverage of approximately 1000 acres. Photographs 2 and 3 show the ground more closely. Numerous craters have been caused by the preparatory laying down of maximum suppressive fire, including the application of 300 per cent saturation with cluster bomb units, a measure required by the Seventh Airforce to protect the slow-flying C123's against hostile ground fire. Many dwellings may be seen in both close-ups, especially in photograph 3. The site of each of the photographs is indicated on the accompanying 1:50,000 scale U.S. Army map.

Population density. The map shows a high population density throughout the target area. In the twenty-seven 1 km^2 grid boxes through which the spraying passed, there are more than 900 dwellings, indicated as small black squares. Detailed comparison of the map with photographs 2 and 3 suggests that the number of dwellings in the target area is at least as great as it was in 1965, the year in which the map was last revised. Assuming, for example, an occupancy of six persons per dwelling, the population in the sprayed area would be approximately 5,000. This corresponds to 180 persons per square kilometer, hardly a low population density.

Expansion of cultivated area. The boundaries of cultivated fields on the enclosed map (and also on a matching 1:20,000 scale pictomap) agree well with the boundaries seen in our photographs, offering no evidence for any major expansion of crop production since 1965. Also, the fields seen in the photographs look well established and not of recent origin.

The question of surplus. The amount of land under cultivation in the target area may be estimated from the map to be approximately 800 hectares, about one hectare for each dwelling. Contrary to the view that a large surplus of food was being grown in the valley, one hectare of mountain land is just about enough to sustain a family unit.

Significance of terraced fields. Authoritative DoD publications on the Montagnard peoples as well as knowledgeable officials in Saigon state that the Montagnards of Quang Ngai, the Hre, have long grown rice on terraced fields.

We realize that this particular crop destruction mission may have been atypical. However, it was cited by the chemical staff officer and other officials as being particularly effective and well planned.

Moreover, our observations lend additional weight to several official studies done in Vietnam which have concluded that nearly all of the food destroyed by the chemical crop destruction program would normally be consumed by civilians, not by enemy soldiers.

As to the scale of the present crop destruction program, we were distressed by the implications of an analysis prepared by the GVN at the province level estimating the quantity of rice and other crops marked for chemical destruction under the 1970-71 herbicide program. Including missions requested by U.S. elements as well as those requested by the Vietnamese themselves, the total quantity of food scheduled for destruction is placed at 14,575 metric tons in Quang Ngai and Quang Tin provinces alone. This should be enough to sustain some 50-70,000 persons for a year. The targets are located mainly in upland regions where Montagnards are the traditional population. The Special Commission for Highland Affairs estimates the total Montagnard population of the two provinces as just under 70,000. Therefore if the areas we inspected are any indicator, the destruction of so much food or even of any substantial fraction of it would have devastating consequences for the Montagnard peoples of Quang Ngai and Quang Tin and for indigenous peoples in other provinces where similar conditions may prevail.

While we were in Quang Ngai province we had several occasions to interview Montagnard refugees whose lands had recently been sprayed with herbicide. We were impressed with the way in which they perceive the use of the chemicals. Apparently when the land is effected by herbicides, the Hre people consider it to be the manifestation of an evil spirit, and according to their tradition will abandon such land in the belief that it has fallen under a curse. Thus the folk beliefs of the Hre may intensify the effects of the crop destruction program on their lives.

Before leaving Vietnam we made a preliminary report of our observations to General Abrams and to Mr. Stephen Winship and Mr. Terence Grant of the Embassy Political Military section. Upon our return, one of us was requested to present a briefing at the State Department in Washington. The briefing took place on October 19 before a working level group consisting mainly of personnel from the Bureau of East Asian and Pacific Affairs and the Bureau of Intelligence and Research. We are also sending copies of this report to Secretary Rogers and to General Abrams.

We strongly hope that our observations can make a positive contribution toward bringing under review a program which seems to us very much in need of it.

Sincerely yours,

Matthew Meselson

John Constable

HE[illegible]ERS
UNITED STATES MILITA[illegible]CE COMMAND, VIETNAM
OFFICE[illegible]MANDER
APO SA[illegible]C 96222

24 AUG 1971

Professor Matthew Meselson
Harvard University
The Biological Laboratories
16 Divinity Avenue
Cambridge, Massachusetts 02138

AUG 30 1971

Dear Professor Meselson:

In reply to your letter of 12 August 1971, this command has no further information to provide in regard to the crop destruction program. The program was terminated earlier this year, as announced in a press release on 20 February 1971.

Public Law 91-441 directed the Secretary of Defense to contract the National Academy of Science for a comprehensive study and investigation of the ecological and physiological effects of the defoliation program in South Vietnam. The National Academy of Science team is expected to arrive in country next month and upon completion of its investigation, will submit a report to the Secretary by 31 January 1972. The Secretary will submit the report to the President and Congress by 1 March 1972.

Sincerely,

CREIGHTON W. ABRAMS
General, United States Army
Commanding

Gmail **Matthew Meselson <msmeselson@gmail.com>**

General Abrams

1 message

Elizabeth Bauernshub <EBauernshub@alisinc.com> Fri, Mar 25, 2016 at 10:26 AM
To: "msmeselson@gmail.com" <msmeselson@gmail.com>

Good morning Mr. Meselson,

General Abrams would like to provide you with the following information regarding your article. Per his note below, if you need additional information, we can arrange for a telephone call.

Thank you,

Elizabeth

Elizabeth Bauernshub

Vice President of Operations

Abrams Learning and Information Systems, Inc.

2800 Shirlington Road, Suite 1100

Arlington, Virginia 22206

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Office: 703 740-5719

Cell: 703 992-5597

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From General John Abrams:

I was not a Colonel in 1970 nor did I serve in I Corps. I was a Captain in 1970 completing the Army's Armor Officers' Advanced Course at Fort Knox, Ky in June of 1970 with follow on assignment to complete my undergraduate degree program at Bowling Green State University, Ohio. I served in 1st Field Force from August of 1967 to June 1969 with specific duty in the 2d Squadron 1st Cavalry Regiment which was deployed to Vietnam in August 1969 with initial assignment to support the 4th Infantry Division to secure main supply route (MSR) 19 East from An Khe to Pleiku and from Kontum along highway 14 North to Ben Het near the Cambodian border within South Vietnam. In the Spring of 1969, the 2-1 Cav was redeployed from the central highlands to the coastal plains of 1st Field Force to secure the main supply route (MSR) of Highway 1 from Phan Thiet to Phang Rang. I joined this Squadron shortly after completing Armor Officer Candidate School and Commissioned a 2Lt with an Armor Cavalry specialty in February 1967. Upon arrival to the Squadron I joined the training and

preparations at Fort Hood, Texas for deployment to Vietnam during the build-up of US Forces. We deployed to Vietnam as a unit travelling aboard the USS Walker arriving in August of 1969 at the seaport city of Quin Yon, and the entry to Vietnam's central highlands by highway 19. I served in combat with this Squadron from August 1967 to June 1969 with 22 months of combat service in Vietnam as an Armored Cavalry Platoon Leader, Executive Officer for an Armored Cavalry Troop, Rifle Company Commander, Armored Cavalry Troop Commander, and Task Force Commander of an Armored Cavalry Troop, an Infantry Company attached from the 173d Airborne Brigade, and a battery of 155mm Artillery. I arrived Vietnam as a 2Lt and returned a Captain. The main supply routes in the central highlands we secured had initially been defoliated by agent orange before our arrival in country in August 1967. As part of the Cavalry mission was to support the clearing operations to create stand-off fields of fire and observation by clearing vegetation by Army Combat Engineers for 100meters on either side of the routes for security forces such as ours to secure

daily convoys of 100 to 150 trucks and tractor trailers carrying food, ammunition, fuel, and medical supplies to major forward operating bases and primary base camps for Army, Air Force, and Special Forces operating in the Central Highlands and on the Bong Song plains of the coast along highway 1 MSR. The Routes were cleared by combat engineers employing large bull dozers because the defoliation operation was not successful to clear the routes for security forces to operate with effective fields of fire and observation. My father and I discussed the effectiveness of the route security program put in place and the effectiveness of the steps to secure the routes during each of his monthly visits to my unit over a two year period. The defoliation program with agent orange was not effective and was replaced by engineers employing large bull dozers that were secure by the Armored and Air Cavalry units. This tactic for Cavalry with attached engineers conducting clearing operations with heavy equipment was very effective and reduced significantly the Viet Cong and North Vietnam interdiction with large scale L shaped

ambushes of battalion size enemy dug in under the cover of thick vegetation near the major supply routes. It also reduced the local Vietcong guerrilla warfare action to conduct harassing and interdiction of MSR's with mines, booby traps, and snipers targeting convoy operations for resupply. After my assignment in 2-1Cav, I was the temporary aide to my father in Saigon for a month before returning home in July 1969. We discussed many of my experiences of the war. The policy for defoliation was one that I remember was a recurring topic at his level. Please pass this to the author and if he needs additional information or wants to discuss with me let me know and we will coordinate a teleconference. Also please pass on my thanks to the author for this piece of work which will expose a mistake in policy that we should never repeat. Many many soldiers have died from cancers from exposure to agent orange. Most of my combat vehicle crew when I first arrived in Vietnam as an Armored Cavalry Platoon Leader in B Troop 2-1 Cav have died of cancer from agent orange. Many more of the Soldiers in the Squadron and attached infantry,

artillery and engineer units along with many commanders and leaders have died from agent orange related cancers. Medical research has yet to develop a cure of cancer from exposure to agent orange. Additionally, the Veterans Administration has recognized the harm of agent Orange and has provided medical benefit for all Soldiers serving in Vietnam for treatment and disability benefit. Thank you, jna

sent to Gen. John Abrams

DRAFT 14 March 2016 -- PLEASE DO NOT CIRCULATE

From Charles and Francis Darwin to Richard Nixon
The Origin and Termination of Anti-plant Chemical Warfare in Vietnam

To be published in the proceedings of the symposium *"100 Years of Chemical Warfare: Research, Deployment, Consequences"* Berlin, 21-22 April, 2015.

Matthew Meselson
Department of Molecular and Cellular Biology
Harvard University
Cambridge, Massachusetts, USA

Abstract: *Anti-plant chemical warfare, the use of chemicals to clear vegetation or destroy food crops as a method of warfare, was conducted on a large scale in the Vietnam War of the 1960s and 1970s. Unlike the anti-personnel CW of World War I, which continued until the Armistice, anti-plant CW in Vietnam was terminated while the war was still underway. Already subject to increasing controversy, its limitation and subsequent termination was precipitated by the appearance in late 1969 of a government-sponsored study suggesting that 2,4,5-T, a component of Agent Orange, the herbicide most heavily used for defoliation, might be teratogenic to humans. In consequence, its use in Vietnam was restricted and then prohibited altogether. Although another herbicide, Agent White, remained briefly in use, all large area defoliation had ceased by May 1970, leaving crop destruction as the remaining form of large-area herbicide operations in Vietnam. After a review of the program requested by the U.S. Ambassador and the Commanding General in Saigon, the Ambassador telegraphed Washington in early December 1970 their decision that chemical crop destruction should be phased out. Although secret, the content of the telegram became known to the press and was published a week later, followed by President Richard Nixon's announcement shortly thereafter that there would be "an orderly yet rapid phaseout of herbicide operations in Vietnam".*

The development of anti-plant CW may be traced to discoveries made by Charles Darwin and his son Francis, described in their book "The Power of Movement in Plants", published in 1880 (Darwin 1880, Holland *et al.* 2009). They found that the bending of oat and canary grass seedlings (specifically, the cotyledons) toward a light source does not occur if the tip of the seedling is shielded from light or excised. Observing that the bending occurs a short distance away from the tip, they concluded that "some influence is transmitted from the upper to the lower part, causing the latter to bend." They also repeated and confirmed disputed experiments by others showing that the downward bending of roots in response to gravity is likewise "due to an influence transmitted from the apex to the adjoining part where the bending takes place."

Investigations early in the 20th century showed the "influence" to be a material substance. Bending in response to light was found not to occur if the tip of a seedling is separated by a thin sheet of mica from the region where bending would otherwise occur but does so if the severed parts are separated instead by a layer of gelatin, through which a chemical substance might diffuse. The isolation and identification of the presumed substance was facilitated by the further discovery that a small block of agar

that has been placed on the upper cut surface of a seedling cut through near the tip, when placed on one side of the lower surface, causes bending in the direction away from that side. This was interpreted to mean that a growth promoting substance adsorbed in the agar block is transported downward on that side of the seedling, causing the observed bending. The angle of bending under defined conditions provided a quantitative assay for the growth promoting substance that was then used to guide its isolation from two sources known to have such activity: human urine and the fungus *Rhizopus suinis*. The highly active substance isolated from both sources was found to be indole-3-acetic acid (IAA). Only much later was it established that IAA is the major naturally-occurring plant hormone involved in heliotropism and geotropism (Whippo and Hangarter 2006, Abel and Theologis 2010, Enders and Strader 2015).

Although IAA stimulates plant growth at low doses, higher doses were found to cause plant death. In 1941, Ezra J. Kraus, chair of the Botany Department at the University of Chicago, proposed that plant growth regulators might therefore find use as selective herbicides in agriculture and began a screen for compounds more stable than IAA that might be used for such purposes. Following Kraus' suggestion, a parallel screening program was undertaken at the U.S. Agricultural Research Center at Beltsville, Maryland under the direction of one of his former doctoral students. Late that year, in a memo written a few days after U.S. entry into WWII, Kraus proposed to a committee of the National Academy of Sciences formed to advise the War Department on biological warfare that a program be established to develop herbicides that might provide a "simple means of destruction of rice crops, the staple food supply of the Japanese" and which applied as "sprays or mists over enemy forests would, through the killing of trees, reveal concealed military depots" (Kraus 1942, Peterson 1967, Troyer 2001).

It had been found in 1942 that 2,4-dichlorophenoxyacetic acid (2,4-D) is a potent stimulator of plant growth (Zimmerman and Hitchcock 1942). But its powerful herbicidal activity and potential as a weed killer, discovered independently in Britain and in the U.S., remained secret until late in the war. Kraus, upon learning of the plant growth activity of 2,4-D, included it in the screens underway at Chicago and at Beltsville, thereby becoming one of the discoverers of its potential for use as an herbicide (Troyer 2001). Conducted under conditions of wartime secrecy, the work at Chicago was done in the University's botany department, just around the corner from the west stands of the track and football field where in the winter of 1942 Enrico Fermi and his colleagues were building the world's first nuclear reactor.

Starting in 1944, a large-scale project to screen chemicals for herbicidal activity and for plant species specificity and to develop methods for their military application was begun by the U.S. Army Chemical Warfare Service at the Army Biological Research Center at Camp (later Fort) Detrick, Maryland, established the year before. The main effort was on crop destruction with only very limited work on defoliation. By late 1945, some one thousand substances had been tested for use against various food crops at Detrick or under its direction in field tests elsewhere in the U.S. Of the agents tested, 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were considered to be the

most effective, although later work showed them to be less so against grain crops. By the end of the war, substantial stocks of 2,4-D and other herbicides and equipment for their dissemination by aircraft had been acquired but were not used in any theatre. After the war, except for a severe cutback in 1957, reversed the following year, research and field testing continued on a substantial scale. Following aerial spray tests conducted in the 1950s at the U.S. Army chemical and biological proving grounds at Dugway, Utah and in 1959 at Camp Drum, New York, formulations of 2,4-D and 2,4,5-T were chosen as defoliants and the plant metabolic disrupter and desiccant cacodylic acid (dimethylarsenic acid), more toxic for grain crops, was selected for use against rice and wheat (Young 2009).

Thus, unlike the anti-personnel CW of World War I, which began with little prior development and no established advocate organization within the military, anti-plant CW in Vietnam was preceded by many years of research, development and testing by a dedicated organization within the U.S. Army. Further, a precedent had been set for anti-plant CW by the use of herbicides, mainly 2,4,5-T, for crop destruction and defoliation in British counterinsurgency operations in Malaya in the early 1950s (Connor and Thomas 1984).

Experimental testing of chemical crop destruction and defoliation in Vietnam began in August 1961 and continued until mid-January 1962, as part of Project Agile of the U.S. Defense Department's Advanced Research Projects Agency (ARPA), supported by the Crops Division of the Army Chemical Corps at Detrick (Brown 1962). The initial impetus for introducing herbicide warfare in Vietnam appears to have come from William H. Godel, an ARPA Deputy Director acting with the encouragement of Vietnam President Ngo Dinh Diem and assisted by the director of Detrick's Crops Division (Godel 1961, Brown 1962, FRUS 1962, Bundy 1972). In the first tests, on August 10, 1961, a mixture of the n-butyl esters of 2,4-D and 2,4,5-T and the isopropyl ester of 2,4,5-T, known as Agent Purple, was sprayed by helicopter over manioc and rice fields and over roadside trees. While the tests were still underway, the Chief of the U.S. Military Assistance Advisory Group in Saigon in October 1961 recommended to the Department of Defense that defoliation and crop destruction be carried out against several designated targets (Olenchuk *et al.* 1963). In the following month, the Joint Chiefs endorsed a plan developed in Saigon to spray 334 square miles of manioc and rice with 2,4,5-T and cacodylic acid and defoliate 200 square miles of forest with 2,4-D and 2,4,5-T, warning, with respect to crop destruction, that "care must be taken to assure that the United States does not become the target for charges of employing chemical or biological warfare" (Buckingham 1982).

Late that same month, on 30 November 1961, responding to recommendations from the Deputy Secretary of Defense and the Secretary of State, President Kennedy agreed in principle to chemical defoliation and crop destruction in Vietnam, but on a far more limited and tightly controlled basis than had been envisaged by the Joint Chiefs, authorizing only a "selective and carefully controlled joint (with the Republic of Vietnam) program of defoliant operations... proceeding thereafter to food denial only if the most careful basis of resettlement and alternative food supply has been created." (Bundy

1961, Buckingham 1982). Limited defoliation on an operational basis (*i.e.*, intended to have a military effect rather than being only developmental) was begun early in January, after Kennedy reduced to only 16 miles the plan for defoliation of about 300 miles of roadside that had been submitted to him by the Departments of Defense and State. Authority to approve defoliation missions was retained in Washington until November 1962, when it was delegated to the U.S. ambassador and the commanding general in Saigon. Crop destruction was not authorized until October 1962. It required State and Defense Department authorization throughout the Kennedy Administration and until July 1964 when it was delegated to Saigon (Collins 1967, Warren 1968, Clary 1971, Buckingham 1982).

Altogether, according to updated estimates, about 73 million liters of various herbicides were sprayed by fixed-wing aircraft and helicopters over an area of approximately 26,000 km^2, 15 percent of the land area of the Republic of Vietnam, most of it sprayed more than once. Most of the area sprayed was coastal or inland forest while about ten percent was crop land. Of the total volume sprayed, about 63 percent was Agent Orange (a mixture of the n-butyl esters of 2,4-D and 2,4,5-T), 28 percent Agent White (a mixture of 2,4-D and a chlorinated derivative of picolinic acid), and 7 percent Agent Blue (cacodylic acid and its sodium salt), and a few percent of other compounds or formulations. After a gradual buildup in herbicide operations in earlier years, nearly 80 percent was dispensed in the four years 1966-1969, followed by a sharp drop in 1970, after the restriction and then cancellation of authorization for the use of Agent Orange (Buckingham 1982, Westing 1984, Stellman *et al.* 2003).

The limitation and subsequent cessation of the use of Agent Orange was precipitated when a study of possible carcinogenic, teratogenic and mutagenic effects of a large number of pesticides and industrial chemicals was brought to the attention of the Administration. The study, dated August 1968 and released to the public the following year, was commissioned by the U.S. National Cancer Institute and done by the Bionetics Research Laboratories of Kensington Maryland (Bionetics 1968). It found that 2,4,5-T administered to pregnant mice and rats consistently caused malformations and death in fetuses and newborns and categorized 2,4,5-T as "probably dangerous".

Although the Bionetics report would have soon come to the attention of the White House one way or another, the swiftness of the response when it was brought to the attention of the President's Science Advisor is noteworthy. In the autumn of 1969, I was given a pre-release copy of the report. Aware of articles in Saigon newspapers claiming that herbicide exposure was causing birth defects and believing that the Administration should be made aware of the Bionetics report, I and a number of colleagues called upon Lee DuBridge, the physicist and former president of CalTech who was then President Nixon's Science Advisor (Hay 1982). After examining the report and while I was still in his office, DuBridge telephoned the Deputy Secretary of Defense, David Packard (co-founder of the Hewlett Packard Corporation), and they agreed on the spot to restrict the use of 2,4,5-T. In a White House press release late that same day, October 29, DuBridge announced that the Defense Department "will restrict the use of 2,4,5-T to areas remote from population"; that the Department of Agriculture "will cancel

registrations of 2,4,5-T for food crops effective January 1"; and that the Departments of Agriculture and Interior "will stop using 2,4,5-T in their own programs" (Nelson 1969a, 1969b). A few days later, DuBridge telephoned me in Cambridge to say that representatives of the Dow Chemical Company had informed him that the likely teratogen was not 2,4,5-T itself but rather a highly toxic impurity, dioxin (2,3,7,8-tetrachlorodibenzodioxin). Dow had known of its toxicity following an outbreak of chloracne among workers at a Dow facility in 1964 (Baughman 1974, Crummett 2002). Dioxin is formed as an impurity in the Dow synthesis procedure for 2,4,5-trichlorophenol, a precursor of 2,4,5-T, particularly if carried out at too high a temperature (Young 2009). Knowing this, Dow had taken precautions to keep the concentration of dioxin in 2,4,5-T below 1 ppm. As found in research done much later, the extreme toxicity of dioxin is associated with its avid binding to a molecular receptor that regulates the expression of numerous genes (IOM 2014, Sorg 2014).

It was later found that the 2,4,5-T employed by Bionetics contained 27 ppm of dioxin. Further tests were therefore undertaken to determine if purer 2,4,5-T also causes birth defects in rodents. Finding that it did so in mice, the Secretaries of Agriculture, Interior, and Health, Education and Welfare agreed in an announcement of April 15, 1970 to suspend registrations for uses of 2,4,5-T on agricultural land and in places likely to entail direct human exposure (US Department of the Interior, 1970). Simultaneously, Packard canceled authorization for all uses of Agent Orange in Vietnam. The cancellation of Agent Orange put a stop to nearly all large area chemical defoliation, leaving only a few occasions on which Agent White, available in only limited supply, was used in this mode, bringing an end to all defoliation, except on the perimeters of fixed US installations, in May, 1970 (Buckingham 1982).

While large area defoliation had ceased, chemical crop destruction continued. Although strongly supported by the Joint Chiefs and the Secretary of Defense (Laird 1970), it was controversial ever since it had been conditionally authorized by President Kennedy in 1961. A 1968 interagency review of the herbicide program ordered by the U.S. ambassador in Saigon, Ellsworth Bunker, concluded that "There is evidence that food shortages, for which crop destruction efforts were partly responsible, have at times created logistical problems for the enemy...The main impact of crop destruction, however, falls upon the civilian population...An estimated 90% of the crops destroyed in 1967 were grown, not by VC/NVA military personnel, but by civilians living there." (American Embassy, Saigon 1968, Clary 1971, Buckingham 1982). The year before, a study of the military utility of the crop destruction program, based on some 2400 interviews conducted with Vietnamese familiar with the activities of the Viet Cong and the North Vietnamese army concluded that "the data consistently suggest that the crop destruction program has not in any major sense denied food to the VC" and that "the crop destruction effort may well be counterproductive. The VC continue to feed themselves while the peasant bears the brunt of the deprivation" (Betts and Denton 1967). In 1972, after all aerial herbicide operations had ceased, Undersecretary of Defense Packard requested the Army Corps of Engineers to conduct an overall evaluation of the military utility of herbicides in Vietnam. Regarding crop destruction, it concluded that "Herbicides destroyed enemy crops, but the enemy was able to

compensate and overcome localized food supply shortages. At most, the crop destruction program harassed the enemy" (ESSG 1972).

An example of problems encountered in attempting to distinguish fields cultivated by military units from fields cultivated by civilians for their own consumption was encountered by a colleague and myself in August 1970. For five weeks in the summer of 1970, I was in Vietnam on behalf of the American Association for the Advancement of Science as part of a small team conducting a preliminary survey of the ecological and health effects of the military use of herbicides in Vietnam—interviewing farmers, photographing sprayed and not-sprayed forest, and collecting environmental and biomedical samples for analysis at Harvard (Constable and Meselson 1971, Meselson *et al.* 1972, Meselson and Baughman 1973). In order to inspect an area where crop destruction had recently taken place, the medical member of our team, Dr. John Constable, and I were flown by helicopter over a river valley in one of the northern provinces where Agent Blue had been sprayed along a 15 km path a few days before {Fig. 1 here}. Flying along the length of the valley on two occasions, we saw rice fields browned by the herbicide but were too high to see much evidence of habitation. As indicators that the valley was an enemy food-production area, not home to a civilian population, the Chemical Corps officer who accompanied us in the helicopter and who had participated in planning the mission explained that the area under cultivation far exceeded the needs of the sparse population in the valley, that there had been a recent major expansion of rice fields, and that the presence of terraced rice fields on the hillsides, a form of rice culture practiced by ethinic Vietnamese but not by the indigenous Montagnard tribespeople, indicated that the area was an enemy crop production site.

Upon returning to the U.S. and examining the high-resolution photographs we had taken from the air and comparing them with U.S. Air Force photographic coverage of the valley done in 1965 and consulting the Army's handbook on the Montagnard tribes of Vietnam and other sources, we found that none of the evidence for enemy crop production cited by the Chemical Corps officer was accurate. We therefore sent a letter describing our observations and a set of our photographs of the sprayed rice fields to Ambassador Bunker and General Creighton Abrams, Commander of military operations in Vietnam (Meselson and Constable 1970) {Fig. 2 here}. I had previously given a briefing on our observations at the State Department Bureau of Intelligence and Research and, in mid-December had described our findings to President Nixon's National Security Advisor, Henry Kissinger (Hydle 1970, Guhin 1970, Buckingham 1982).

In November 1970, Bunker and Abrams initiated a review of the herbicide program with particular emphasis on crop destruction (Interagency 203 Committee 1970). After considering the resulting report they sent a telegram to Washington on December 9 saying they had decided that the crop destruction program should be phased out (Bunker 1970). Their recommendation leaked to the press and was published the following week (Jay 1970). On December 26, the day on which we reported our observations in Vietnam to the annual meeting of the American

Association for the Advancement of Science in Chicago (Boffey 1971), President Nixon announced that "Ambassador Bunker and General Abrams are initiating a program for an orderly, yet rapid phase-out of the herbicide operations" and that during the phase-out, the use of herbicides in Vietnam would be restricted to perimeters of firebases and US installations or remote unpopulated areas (Office of the White House Press Secretary 1970). The last crop destruction mission was flown on January 7, 1971 (Young 2009). Thus, the large area use of herbicides in Vietnam, already greatly reduced in 1970, came to an end at the start of the following year, two years before the Paris ceasefire agreement of January 1973 terminating direct US combat support for the Republic of Vietnam.

Two years later, in April 1975, President Gerald Ford proclaimed that "The United States renounces, as a matter of national policy, first use of herbicides in war except use, under regulations applicable to their domestic use, for control of vegetation within U.S. bases and installations or around their immediate defensive perimeters." (Executive Order, 1975).

Postscript. While in Vietnam, I heard a spectrum of opinion from military officers, from pro to con, regarding the military utility of the herbicide program. Particularly noteworthy was the view expressed personally to me by General Creighton Abrams in his office on September 3, 1970. "Do you want to know what I think? I think it's 's---'", adding that his son John, then a colonel in I-Corps was of the same view. When asked why the program continued even though he was Commander of U.S. forces in Vietnam, Abrams replied that the decision to do so was made in Washington.

Figure 1. Aerial photograph of a portion of a valley sprayed with Agent Blue in August 1970. Many small dwellings may be seen throughout the valley. Terraced fields may be seen on the hillsides. From the Meselson CBW Archive.

Figure 2. Letter sent to Ambassador Ellsworth Bunker, General Creighton Abrams and Secretary of State William Rogers 12 November 1970. From the Meselson CBW Archive.

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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AAAS HERBICIDE ASSESSMENT COMMISSION
BOTANICAL MUSEUM, HARVARD UNIVERSITY
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MATTHEW S. MESELSON, CHAIRMAN
ARTHUR H. WESTING, DIRECTOR

12 November 1970

The Honorable Ellsworth Bunker
American Ambassador
Saigon, Republic of Vietnam
APO San Francisco, California 96243

Dear Ambassador Bunker,

On behalf of the Herbicide Assessment Commission of the American Association for the Advancement of Science, we wish to express our appreciation for the generous assistance provided by the Embassy during our recent tour of the Republic of Vietnam.

We are now preparing our report for presentation to the AAAS at the end of December and will send a copy to you as soon as it is available. Before that time, however, we wish to relay some observations that we believe merit your more immediate attention because they challenge the basis of the current chemical crop destruction program.

On August 21 and 28 we overflew an area in Quang Ngai province where chemical crop destruction operations had been conducted a few days before. The responsible chemical operations staff officer accompanied us on one of the overflights, and we spoke at length with other officers and civilian officials on the scene. It was explained to us that the targets were VC/NVA crop production areas and that most of the food destroyed would otherwise have been consumed by enemy forces. The reasons given for this assessment were that

1. The target area had only a very low population density.

2. The area under cultivation had expanded strikingly in recent years.

3. The cultivated area was much larger than that needed to support the small indigenous population.

4. The existence of numerous terraced rice fields indicated the influx of VC/NVA food production units, since the Montagnards who comprise the native population do not practice terracing.

Our observations are sharply at variance with all four of these points.

Background information. One of the target areas is shown in photograph 1. Three C123 aircraft sprayed herbicide along the Song Re river valley from map coordinates BS 3455 to BS 3543. The photograph was taken near the latter coordinate, looking northward up the valley. The spray swaths are generally visible as brown streaks. Spraying was conducted continuously for a distance of about ten miles, resulting in coverage of approximately 1000 acres. Photographs 2 and 3 show the ground more closely. Numerous craters have been caused by the preparatory laying down of maximum suppressive fire, including the application of 300 per cent saturation with cluster bomb units, a measure required by the Seventh Airforce to protect the slow-flying C123's against hostile ground fire. Many dwellings may be seen in both close-ups, especially in photograph 3. The site of each of the photographs is indicated on the accompanying 1:50,000 scale U.S. Army map.

Population density. The map shows a high population density throughout the target area. In the twenty-seven 1 km^2 grid boxes through which the spraying passed, there are more than 900 dwellings, indicated as small black squares. Detailed comparison of the map with photographs 2 and 3 suggests that the number of dwellings in the target area is at least as great as it was in 1965, the year in which the map was last revised. Assuming, for example, an occupancy of six persons per dwelling, the population in the sprayed area would be approximately 5,000. This corresponds to 180 persons per square kilometer, hardly a low population density.

Expansion of cultivated area. The boundaries of cultivated fields on the enclosed map (and also on a matching 1:20,000 scale pictomap) agree well with the boundaries seen in our photographs, offering no evidence for any major expansion of crop production since 1965. Also, the fields seen in the photographs look well established and not of recent origin.

The question of surplus. The amount of land under cultivation in the target area may be estimated from the map to be approximately 800 hectares, about one hectare for each dwelling. Contrary to the view that a large surplus of food was being grown in the valley, one hectare of mountain land is just about enough to sustain a family unit.

Significance of terraced fields. Authoritative DoD publications on the Montagnard peoples as well as knowledgeable officials in Saigon state that the Montagnards of Quang Ngai, the Hre, have long grown rice on terraced fields.

We realize that this particular crop destruction mission may have been atypical. However, it was cited by the chemical staff officer and other officials as being particularly effective and well planned.

Moreover, our observations lend additional weight to several official studies done in Vietnam which have concluded that nearly all of the food destroyed by the chemical crop destruction program would normally be consumed by civilians, not by enemy soldiers.

As to the scale of the present crop destruction program, we were distressed by the implications of an analysis prepared by the GVN at the province level estimating the quantity of rice and other crops marked for chemical destruction under the 1970-71 herbicide program. Including missions requested by U.S. elements as well as those requested by the Vietnamese themselves, the total quantity of food scheduled for destruction is placed at 14,575 metric tons in Quang Ngai and Quang Tin provinces alone. This should be enough to sustain some 50-70,000 persons for a year. The targets are located mainly in upland regions where Montagnards are the traditional population. The Special Commission for Highland Affairs estimates the total Montagnard population of the two provinces as just under 70,000. Therefore if the areas we inspected are any indicator, the destruction of so much food or even of any substantial fraction of it would have devastating consequences for the Montagnard peoples of Quang Ngai and Quang Tin and for indigenous peoples in other provinces where similar conditions may prevail.

While we were in Quang Ngai province we had several occasions to interview Montagnard refugees whose lands had recently been sprayed with herbicide. We were impressed with the way in which they perceive the use of the chemicals. Apparently when the land is effected by herbicides, the Hre people consider it to be the manifestation of an evil spirit, and according to their tradition will abandon such land in the belief that it has fallen under a curse. Thus the folk beliefs of the Hre may intensify the effects of the crop destruction program on their lives.

Before leaving Vietnam we made a preliminary report of our observations to General Abrams and to Mr. Stephen Winship and Mr. Terence Grant of the Embassy Political Military section. Upon our return, one of us was requested to present a briefing at the State Department in Washington. The briefing took place on October 19 before a working level group consisting mainly of personnel from the Bureau of East Asian and Pacific Affairs and the Bureau of Intelligence and Research. We are also sending copies of this report to Secretary Rogers and to General Abrams.

We strongly hope that our observations can make a positive contribution toward bringing under review a program which seems to us very much in need of it.

Sincerely yours,

Matthew Meselson

John Constable