Herbicides in Vietnam: AAAS Study Finds Widespread Devastation

The AAAS team that has been investigating the military use of herbicides in Vietnam believes the American spraying program has caused "extremely serious harm" to the land and to some of the peoples of the war-torn country. The team has also come up with evidence of rather shocking deficiencies in the precautions taken by U.S. military authorities to protect civilian populations from needless attack under the Army's crop destruction program.

These and other findings were made public last week when the AAAS Herbicide Assessment Commission, headed by Harvard biologist Matthew S. Meselson, presented a preliminary report to the AAAS annual convention in Chicago. Meselson was appointed by the AAAS board in December 1969 to prepare a detailed plan for determining the impact of herbicides on the land and people of Vietnam. Operating under a budget of $80,000, he and his colleagues reviewed the pertinent literature, consulted with numerous experts, and made a 5-week inspection tour of South Vietnam this past summer. Their formal reports to the AAAS annual convention were guardedly conservative in tone, but their findings added up to a charge that the military use of herbicides has been considerably more destructive than anyone had previously imagined. Among the assertions:

► One-fifth to one-half of South Vietnam's mangrove forests, some 1400 square kilometers in all, have been "utterly destroyed," and even now, years after spraying, there is almost no sign of new life coming back.

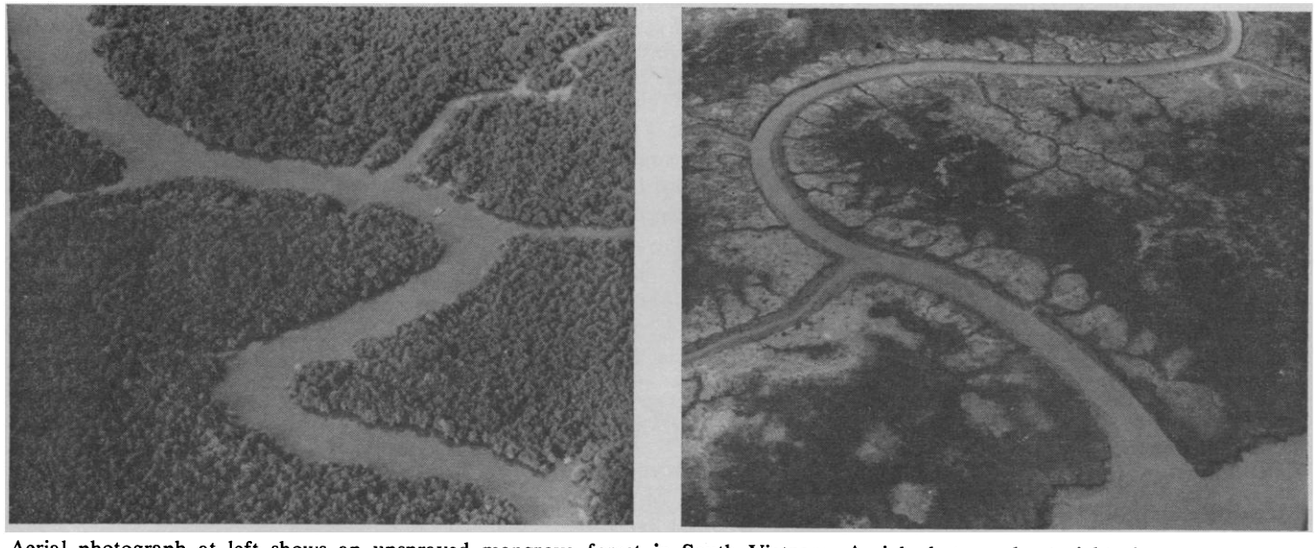
► Perhaps half the trees in the mature hardwood forests north and west of Saigon are dead, and a massive invasion of apparently worthless bamboo threatens to take over the area for decades to come.

► The Army's crop destruction program, which seeks to deny food to enemy soldiers, has been a near total "failure," because nearly all the food destroyed would actually have been consumed by civilian populations, particularly the Montagnard tribes of the Central Highlands.

► There is no definite evidence of adverse health effects, but further study is needed to determine the reason for a high rate of stillbirths in one heavily sprayed province and for an increase in two particular kinds of birth defects which were reported at a large Saigon hospital and which were coincident with large-scale spraying.

The AAAS team made no effort to assess the military usefulness of herbicides and, thus, came to no official conclusion as to whether the program should be continued. But individual members of the AAAS team clearly felt that the damaging consequences they had uncovered called the value of the program into question. Last November two members of the team sent to the highest U.S. officials in Saigon and Washington a letter challenging the basis of the crop destruction program. And at the AAAS convention, Arthur H. Westing, a botanist and commission member, urged that the herbicide program be phased out immediately because of the ecological and economic damage it is causing. Meselson, the head of the study, told *Science* in an interview that, while there is no proof that the herbicide program has caused substantial medical harm to the people in South Vietnam, there is no question that it has caused "extremely serious harm" both to the land and to the Montagnards who have been deprived of food.

Not everyone who heard the data presented by Meselson and his colleagues was prepared to draw the same conclusions from the evidence, however. Biologist Kenneth V. Thimann, a herbicide specialist and AAAS board member, said that nothing he had heard had changed his opinion, expressed publicly in 1968, that the Army's use of chemicals "for defoliation of forest cover probably represents a military device for saving lives that has an unprec-



Aerial photograph at left shows an unsprayed mangrove forest in South Vietnam. Aerial photograph at right shows a mangrove forest which was subjected to herbicide spraying in 1965. One spraying kills essentially all trees. The larger trunks appear to have been removed by the local population for firewood.

A mangrove forest that was sprayed with herbicides sometime before 1968.

edented degree of harmlessness to the environment." And Brig. Gen. William W. Stone, Jr., who recently retired as director of chemical and nuclear operations for the U.S. Army, said that he personally still believes that "our use of herbicides has not created any permanent ecological damage of any significance in Vietnam."

White House Reacts

Nevertheless, the study seems already to have achieved a political impact. On 26 December, the very day the AAAS convention opened, the White House, which had previously been informed that Meselson would denounce the crop destruction program, announced that authorities in Saigon were "initiating a program for an orderly, yet rapid, phase-out of the herbicide operations." The White House said that, during the phase-out period, the use of herbicides would be restricted to the perimeter of U.S. bases or to "remote, unpopulated areas." Further information supplied to reporters indicated that authorities planned to use up the existing stockpile of herbicides on these two restricted uses and then drop the spraying program entirely, probably by next spring.

Though the White House made no mention of the AAAS, several knowledgeable Washington operatives—including Herbert Scoville, Jr., former deputy director of the Central Intelligence Agency and a former arms control official, and Representative Richard D. McCarthy (D–N.Y.), a key activist on the herbicide question—suggested that the AAAS study had been a major factor spurring the White House announcement. But lingering doubts remained about the sincerity of White House intentions. Both Scoville and McCarthy argued that, if the herbicide program is bad enough to be dropped, it should be dropped immediately, instead of after the existing stockpiles are used up. And Scoville questioned whether restricting the herbicides to "remote, unpopulated areas" would really end the destruction of civilian crops since the Army has contended all along that it only destroys crops in "remote, unpopulated areas." In an apparent effort to spur still faster action, the AAAS council adopted a resolution commending the government for its announcement but urging that there be an "immediate discontinuation" of herbicide spraying in Indochina.

Large Spraying Program

The herbicide program in Vietnam has been operating for almost a decade now, and it has developed into a sizable operation over the years. The program began in an experimental way in 1961, became operational in 1962, and then grew rapidly to a peak in 1967, before declining somewhat in 1968 and 1969. Over this 9-year period, about one-seventh of the land area of South Vietnam—equivalent in size to the state of Massachusetts—has been treated with herbicides, most of them sprayed from low-flying C-123 cargo aircraft that made more than 19,000 individual spray flights between 1962 and 1969. About 90 percent of the herbicide was dropped on forest land and about 10 percent on crop land.

The chief herbicide used against forests has been Agent Orange, a mixture of 2,4-D and 2,4,5-T, but the use of Orange was ordered stopped last April because of laboratory tests indicating that 2,4,5-T is teratogenic. The next most commonly used agent against forests has been Agent White, a mixture of 2,4-D and picloram, while the herbicide most commonly used against crops has been Agent Blue, a solution of cacodylic acid, which is an arsenic compound. The AAAS board expressed particular concern in 1968 about the use of arsenicals on crops.

Several brief studies of the herbicide program have been made in recent years, some by the military or by the U.S. mission in Vietnam, and others by the forestry branch of the U.S. Agency for International Development, by an expert from the Agricultural Research Service, and by such nongovernment scientists as Gordon H. Orians and Egbert W. Pfeiffer, who visited Vietnam for 2 weeks in 1969. But Meselson and his colleagues seem unquestionably to have conducted the most extensive independent analysis yet made. Their study was intended to come up with some preliminary findings and to result in the preparation of a detailed plan for determining more accurately the short- and long-term consequences of the use of herbicides on the land and people of South Vietnam. Meselson and his colleagues reviewed the pertinent literature, solicited information and advice from more than 200 experts in this country and elsewhere, held a 5-day conference with 23 experts at Woods Hole, Massachusetts, and then conducted on-site inspections in South Vietnam for a 5- to 6-week period in August and September. Those making the trip to Vietnam included Meselson, a professor of biology at Harvard who has long played a major role in assessing the impact of chemical and biological warfare; Westing, a forestry specialist and chairman of biology at Windham College, Vermont, who had previously studied the impact of defoliation in Cambodia; John D. Constable, professor of surgery at Harvard Medical School, who had made two previous health surveys in Vietnam; and Robert E. Cook, Jr., a graduate student in ecology at Yale. The team's observations extended into several areas not previously studied and, in some instances, differed significantly with prior reports. The key findings were as follows:

Crop Destruction. The AAAS team conducted what appears to be the first independent, nongovernmental study of

the crop destruction program and concluded that it has been a failure because of poor intelligence.

Some 2000 square kilometers of land have been sprayed to destroy crops. At the request of the AAAS team, specialists on Vietnam in the Agriculture Department estimated that this entailed destruction of enough food to feed 600,000 persons for a year. The anti-crop spraying has been largely confined to the food-scarce Central Highlands, which has a population of only about 1 million, mostly Montagnards, a tribal people disliked by the lowland Vietnamese who are active in helping to plan the spraying missions.

The AAAS team was twice flown over an area in Quang Ngai province where crop destruction operations had been conducted only a few days before. They were accompanied by the chemical operations officer who had planned the missions, and they were assured by him that the fields destroyed were growing food for the enemy. The reasons given for this assessment were that the target area was virtually uninhabited (supposedly less than eight persons per square kilometer); the area under cultivation had expanded strikingly in recent years; the cultivated area was much larger than needed to support the supposedly small indigenous population; and there were numerous terraced rice fields—which indicated the presence of the enemy, since the native Montagnards supposedly don't practice terracing.

All four contentions, the AAAS team later concluded, were in error. Though the officer said there were no dwellings below and none could be seen from the air, aerial photographs taken by the AAAS team and a map issued in 1965 both indicate more than 900 dwellings in the area—suggesting a population of more than 5000, or about 180 persons per square kilometer. Moreover, the boundaries of cultivated fields seen in the photographs compared closely with the boundaries on the 1965 map, indicating no major crop expansion over the past 5 years. The AAAS team concluded that the land under cultivation was just about enough to support the people apparently living there. They also learned from other military sources that the Montagnards in question have grown rice on terraced fields for a long time. Summing up, the AAAS team said: "Our observations lead us to believe that precautions to avoid destroying the crops of indigenous civilian populations have been a failure and that nearly all the food destroyed would actually have been consumed by such populations."

In the give-and-take of debate at the AAAS convention, it was also learned that several classified studies conducted under military auspices since 1967 have come to a similar conclusion. The one major classified study which came to an opposite conclusion and asserted that the program was hurting the enemy but was having little impact on civilian food supplies was marred, according to Meselson, by a simple error in arithmetic, which threw its results off by a factor of 100.

The AAAS team also concluded that continuation of the crop destruction program would have "devastating consequences for the Montagnard peoples," not only by depriving them of food, but also because of their animist beliefs. Interviews with Montagnard refugees whose lands had recently been sprayed revealed that they regard the spray operations as the manifestation of an evil spirit. Some abandon their land in the belief that it has fallen under a curse; others destroy their water buffalo, the chief source of wealth, believing them to be infected or feeling a sacrifice is needed.

Brig. Gen. Stone, in attempting to rebut the AAAS team's findings, claimed that the Army's "best intelligence" indicated that the houses seen in Mes-

State Radiation Law Loses in Court

A Minnesota federal court judge has ruled that a state has no right to establish radiation standards stricter than those set by the Atomic Energy Commission (AEC). The ruling came as a result of a suit filed by the Northern States Power Company, which is building a nuclear generating plant in Monticello, Minnesota. The power company sought to contravene new standards on radiation emissions, which were set by the Minnesota Pollution Control Agency (MPCA). The decision is bound to affect efforts by other states to tighten controls on radioactive pollution.

The Minnesota controversy began in 1968 when the new plant sought a waste disposal permit from MPCA (see *Science*, 7 March 1969). Objections by local scientists led MPCA to hire an outside consultant to study the situation. The consultant, Ernest Tsivoglou, said that the AEC standards did not take into account the cumulative effect of radiation when other plants are built in the area (Monticello is some 40 miles up the Mississippi River from Minneapolis–St. Paul), nor did they make allowance for possible radiation damage to organisms other than human ones.

The judge, Edward J. Devitt, based his ruling on a 1959 amendment to the 1954 Atomic Energy Act, which gives the AEC authority over construction and operation of any production or utilization facility, and on a congressional report which stated that licensing and control of reactors is the "exclusive responsibility" of the AEC. Whether the standards permitted deviation, said the judge, was solely for the Congress or the AEC itself to decide. The state argued that the right to strengthen atomic power regulations fell within its constitutional mandate to oversee the health and safety of its citizens.

The maximum permissible radiation endorsed by the state is only 2 percent of that sanctioned by AEC. According to a company spokesman, Peter Cook, Tsivoglou's recommendations embraced the "ideal" standards set forth in General Electric's design for the plant, plus some "strange" ideas of his own. Cook said the new regulations are "in conflict with AEC standards in some instances and in others unworkable."

The MPCA plans to appeal the decision. Its stand in court was accompanied by "friend of the court" briefs from nine states—Illinois, Maryland, Michigan, Missouri, Pennsylvania, Texas, Vermont, Virginia, and Wisconsin—and from the Southern Governors Conference, which represents 18 states and territories. The MPCA has expressed fear that the ruling may affect other state standards which govern the amounts of radiation allowable in all state institutions, including hospitals and research centers.—CONSTANCE HOLDEN

elson's photographs were unoccupied. He said the fields were most likely cultivated by persons under Vietcong control, since the fields had been sprayed at least once annually for several years and the native Montagnards, fearing evil spirits, would presumably have moved off the land if they had been cultivating it. Stone also said the fields are obviously important to the Vietcong because the enemy has allowed its hidden antiaircraft guns to give away their positions in order to fire at the spray planes. However, Meselson cited evidence indicating that the dwellings were indeed occupied. The matter was left unresolved.

Total Annihilation

Mangrove Forests. The AAAS team seems to have been the only group in recent years to conduct an investigation on the ground in the devastated mangrove forests along the coast southeast of Saigon. For some unknown reason, virtually the entire plant community is killed outright by a single spraying, leaving a "weird and desolate" scene of "total annihilation." Furthermore, again for an unknown reason, herbicide attack appears to prevent the reestablishment of any new plant community. The AAAS team that went in on the ground found that what had previously appeared, from the air, to be regeneration was actually only a few surviving plants from the previous stand. The only sign of new life was a few worthless ferns and shrubs that had invaded the area—the fern being considered a serious pest elsewhere in Southeast Asia. This lack of new plant life was deemed one of the most significant findings of the AAAS study by Fred H. Tschirley of the Agricultural Research Service, who had conducted an earlier study of defoliation in Vietnam. "It was surprising to me—I didn't expect it," Tschirley told *Science*. "I had assumed regeneration would be taking place." Westing said the sprayed areas seem impervious to recolonization by plants for at least 6 years, and he estimated it will take decades to restore them. The AAAS team also detected the beginnings of erosion along the waterways of the mangrove area, but it is too early to tell how serious this problem will become.

Whether the destruction of the mangrove forests matters in a significant way has not been completely established. Westing acknowledged that the mangrove areas are "inhospitable, seemingly impenetrable, and outwardly unimportant." However, they do serve as home for tens of thousands of people; they serve as a source of firewood and charcoal; they provide cover and food for various birds, fish, and crustaceans; and they continually build up and stabilize the shoreline. The AAAS team recommended that an attempt be made to estimate what impact the loss of mangroves would have on the fishing industry, before deciding how much of the former mangrove area should be replanted to tidal forests and how much devoted to other purposes.

Tropical Hardwood Forests. The AAAS team was unable to get into these forests on the ground, as some previous investigators had, but the team inspected the forests from the air in a wide arc north and west of Saigon, from Cambodia to the sea. The team's most important finding was an "eyeball" observation that more than half of the forest in three provinces over which they flew was "very severely damaged," with the trees dead and bamboo or tenacious grasses spreading over the ground in their place. The extent of destruction and of bamboo invasion far exceeded previous estimates that perhaps 10 percent of the trees were being killed in areas sprayed once. The team learned from Vietnamese forestry experts that the invading bamboo species is almost certainly worthless and expensive to eradicate.

Westing, the team's forestry expert, was unable to make the aerial inspection trip. He therefore put together his report, using previously published data that is more conservative than the "eyeball" impresssions of his colleagues. Westing concluded that about 35 percent of South Vietnam's 14 million acres of dense forest have been sprayed one or more times and that, as a result, 6.2 billion board feet of merchantable timber have thus far been killed by herbicides. This is the equivalent of South Vietnam's entire domestic timber needs, based on current demand, for the next 31 years. Though Westing acknowledged that not all of this timber would actually have been cut and used, he said that most of the destruction has occurred on prime timber lands close to the Saigon market. The lost timber represents about $500 million in stumpage taxes that would otherwise have accrued to the South Vietnamese government. Westing suggested that it may take decades for some of the damaged forest lands to recover, partly because the invading bamboo and grasses may be difficult to eradicate, and partly because nutrient minerals previously tied up in forest vegetation may have been released and then leached out of sprayed forests by the heavy tropical rains.

Health Effects. Constable, the team's medical expert, found "no definite evidence" of adverse health effects caused by the spraying, but the AAAS team did find deficiencies in a recent study by the U.S. Army and the South Vietnamese Ministry of Health, which tended to exonerate herbicides from causing birth defects. The Army study, based on South Vietnamese hospital records for the past 10 years, reported a downward trend in stillbirths, placental tumors, and malformations, coincident with the peaking of herbicide spraying. However, the AAAS team subtracted the Saigon data from the overall figures and discovered that the Army study actually shows an increase in all three defects for the rest of the country, where the population has been more heavily exposed to herbicides. Still, the AAAS team acknowledged that it would be "totally incorrect" to consider this proof of the effect of herbicides, since many other factors could account for the trends.

Army Study Incomplete

The team evaluated in detail the birth records in Tay Ninh, a very heavily defoliated province, and discovered that the records used for the Army study were grossly deficient. Whereas the Army group had reported 208 stillbirths in the province in 1968 and 1969, the AAAS team, using more complete records, noted 351. The AAAS team found that Tay Ninh City Provincial Hospital showed a stillbirth rate of 64 per thousand, higher than any provincial hospital reported by the Army study and well above the country-wide average of 31.2 per thousand. The AAAS team also discovered that Saigon Childrens Hospital had experienced a "disproportionate rise" in two birth defects—pure cleft palate and spina bifida—in 1967 and 1968. But the team stressed that neither effect could safely be attributed to the impact of herbicides, and it called for further studies to elucidate the cause of the unexplained trends. From interviews with key Vietnamese health officials, the team concluded that there have been no strikingly new deformities (along the lines of the thalidomide baby tragedy) observed in heavily sprayed areas of Vietnam.

Food Chain Contamination. The

AAAS team seems to have been the first group of any kind—military or civilian—to collect samples of shrimp, fish, human milk, human hair, human fat, and other materials so that they could be analyzed for the presence of herbicides or their breakdown products. The team is still struggling to develop analytical techniques capable of detecting extremely low concentrations of dioxin, an impurity in Agent Orange that is so toxic that tiny amounts of it concentrated in the food chain could cause health problems. The AAAS team concluded it is "not impossible" that significant amounts of dioxin are entering the Vietnamese diet, but Tschirley, of the Agricultural Research Service, reported new experimental results which indicated that dioxin is photodegraded quickly, does not accumulate in the soil, and is picked up only in small amounts by plants. Tschirley said he doesn't believe there is a "very real possibility" that enough dioxin is being concentrated to cause damage, but he acknowledged that further tests must be made to determine whether dioxin accumulates in the fatty tissues.

Military Considerations. The AAAS did not consider the military utility of herbicides, but Gen. Stone, in rebutting the AAAS findings, argued that "the benefits have outweighed the adverse effects" and that "herbicides have been militarily useful and have saved many lives." Stone said that defoliation of thick undergrowth has reduced the incidence of ambushes and surprise attacks and has enabled the Army to keep tabs on enemy movements. He also said that crop destruction has "hurt the enemy's ability to live off the people and the land." This is indicated, he said, by the fact that enemy defectors have complained of food shortages. Meselson countered by arguing that Stone's evidence was essentially anecdotal and that it was not clear just what factors had brought about a decrease in ambushes in a given area. Meselson said he had heard a spectrum of opinion from military officers—ranging from pro to con—concerning the military usefulness of the herbicide program.

Psychological. The AAAS team seems to have been the first nongovernmental group to conduct long interviews with farmers and village officials concerning the herbicide program. Samuel Popkin, assistant professor of government at Harvard, who directed the interviewing, said the spraying has had "a very negative psychological impact" on the farmers. He said many peasants feel the United States is deliberately trying to destroy the rural economy to make the farmers dependent on the United States. Later, Gen. Stone told *Science* he found the psychological results reported by Popkin—and by the rest of the AAAS team on the basis of interviews with Montagnards—to be the most dramatic finding of the AAAS study. "They're saying the herbicides have had a negative impact that detracts from our overall program rather than adds to it," he said. "I had frankly never realized there was this psychological impact."

The AAAS team was unable to obtain from the military precise data as to where herbicides had been sprayed, when, and how much herbicide of what type had been used. Meselson said the fact that this information was considered classified greatly hampered his group's efforts to determine, for example, precisely which populations should be examined for possible health effects and precisely which areas of the forest should be examined for possible evidence of laterization (no evidence of laterization was seen by the group). However, the Pentagon has said that it will declassify the information if a full-scale study of the herbicide program is made—as is currently planned—by the National Academy of Sciences (see *Science*, 2 October 1969, p. 43).

The AAAS team's final report will be presented after analysis of the samples is completed, perhaps in a few months time. Meselson stresses that the focus for future action should be shifted away from assessing harm and toward finding ways to repair the damage done, preferably by drawing on the talents of Vietnamese scientists. He suggested that one possible way to get rid of the invading bamboo, for example, might be to plant long north-south lines of shade trees in the devastated forests in hopes that the shadows would force the bamboo to recede on both sides. If these and other techniques can be found to restore the devastated areas, then the AAAS study might well merit the praise lavished on it by one member of the convention audience who stood up and exclaimed that the herbicide study is "the greatest service the AAAS has ever performed for the human race."—PHILIP M. BOFFEY

AAAS Convention: Radicals Harass the Establishment

Science, Technology. We declare its use a sham. And subject all who use it ill to the witches' damn.—A hex pronounced on the AAAS convention by the Women's International Terrorist Conspiracy from Hell (WITCHES).

Chicago. Glenn T. Seaborg, president-elect of the AAAS, took the advice of convention officials and fled from a meeting room to avoid being "indicted" by young radicals; Edward Teller, the so-called "father of the H-bomb," was repeatedly badgered despite the two bodyguards who tailed him everywhere; Mrs. Garrett Hardin, wife of the distinguished biologist, got so angry that she poked a young radical with her knitting needle; Jerry Wilson, Washington, D.C., police chief, backed out of a speaking commitment for fear he'd be heckled; and Miss Metric System, a bikini-clad lass who was promoting the metric system with her own impressive measurements, was put to rout by women radicals who resented the "exploitation" of her assets by admiring photographers.

That's the kind of AAAS annual meeting it was—sprinkled with disruptions and headline-grabbing incidents as a loosely organized band of young radicals sought to turn the attention of the AAA$, as they call it, toward the need for a new "people's science." This was the second straight year of disruptions at the AAAS annual meeting, and while the radicals claimed moderate success at getting their message across, their disruptions raised the hackles of