PROHIBITING MILITARY WEATHER MODIFICATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON OCEANS AND INTERNATIONAL ENVIRONMENT

OF THE

COMMITTEE ON FOREIGN RELATIONS UNITED STATES SENATE

NINETY-SECOND CONGRESS

SECOND SESSION

ON

S. Res. 281

EXPRESSING THE SENSE OF THE SENATE THAT THE U.S. GOVERNMENT SHOULD SEEK THE AGREEMENT OF OTHER GOVERNMENTS TO A PROPOSED TREATY PROHIBITING THE USE OF ANY ENVIRONMENTAL OR GEOPHYSICAL MODIFICATION ACTIVITY AS A WEAPON OF WAR, OR THE CARRYING OUT OF ANY RESEARCH OR EXPERIMENTATION WITH RESPECT THERETO

JULY 26 AND 27, 1972

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PROHIBITING MILITARY WEATHER MODIFICATION

WEDNESDAY, JULY 26, 1972

UNITED STATES SENATE,
SUBCOMMITTEE ON OCEANS AND
INTERNATIONAL ENVIRONMENT OF THE
COMMITTEE ON FOREIGN RELATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m. in room 4221, New Senate Office Building, Senator Claiborne Pell (chairman) presiding.

Present: Senators Pell and Case.

Senator PELL. The subcommittee will come to order.

OPENING STATEMENT

This morning the Subcommittee on Oceans and International Environment opens its public hearings on Senate Resolution 281.

This resolution expresses the sense of the Senate that the United States should seek the agreement of other Governments to a proposed treaty prohibiting the use of any environmental or geophysical modification activity as a weapon of war.

A number of Senators have done me the honor of joining with me in cosponsoring this resolution.

I offered this resolution because it was becoming increasingly clear that the potential for offensive military uses of environmental and geophysical modification is very real.

There was also a growing concern among knowledgeable members of the scientific community that development and use of these modification techniques, without limitation, could have awesome consequences.

(Text of S. Res. 281 and coordinated executive branch comments follow:)

[S. Res. 281, 92d Cong., second sess.]

RESOLUTION Expressing the sense of the Senate that the United States Government should seek the agreement of other governments to a proposed treaty prohibiting the use of any environmental or geophysical modification activity as a weapon of war, or the carrying out of any research or experimentation with respect thereto

Whereas there is vast scientific potential for human betterment through environmental and geophysical controls; and

Whereas there is great danger to the world ecological system if environmental and geophysical modification activities are not controlled or if used indiscriminantly; and

Whereas the development of weapons-oriented environmental and geophysical modification activities will create a threat to peace and world order; and

Whereas the United States Government should seek agreement with other governments on the complete cessation of any research, experimentation, or use of any such activity as a weapon of war: Now, therefore, be it

Resolved, That it is the sense of the Senate that the United States Government should seek the agreement of other governments to the following treaty providing for the complete cessation of any research, experimentation, and use of any environmental or geophysical modification activity as a weapon of war:

"The Parties to this Treaty,

"Recognizing the vast scientific potential for human betterment through environmental and geophysical controls,

"Aware of the great danger to the world ecological system of uncontrolled and indiscriminate use of environmental and geophysical modification activities,

"Recognizing that the development of weapons-oriented environmental and geophysical modification techniques will create a threat to peace and world order,

"Proclaiming as their principal aim the achievement of an agreement on the complete cessation of research, experimentation, and use of environmental and geophysical modification activities as weapons of war,

"Have agreed as follows:

"ARTICLE I

"(1) The States Parties to this Treaty undertake to prohibit and prevent, at any place, any environmental or geophysical modification activity as a weapon of war;

"(2) The prohibition in paragraph 1 of this article shall also apply to any research or experimentation relating to the development of any such activity as a weapon of war;

"(3) The States Parties to this Treaty undertake not to assist, encourage or induce any State to carry out activities referred to in paragraph 1 of this article and not to participate in any other way in such actions.

"ARTICLE II

"In this Treaty, the term 'environmental or geophysical modification activity' includes any of the following activities:

"(1) any weather modification activity which has as a purpose, or has as one of its principal effects, a change in the atmospheric conditions over any part of the earth's surface, including, but not limited to, any activity designed to increase or decrease precipitation, increase or suppress hail, lightning, or fog, and direct or divert storm systems;

"(2) any climate modification activity which has as a purpose, or has as one of its principal effects, a change in the long-term atmospheric conditions over any part of the earth's surface;

"(3) any earthquake modification activity which has as a purpose, or has as one of its principal effects, the release of the strain energy instability within the solid rock layers beneath the earth's crust;

"(4) any ocean modification activity which has as a purpose, or has as one of its principal effects, a change in the ocean currents or the creation of a seismic disturbance of the ocean (tidal wave).

"ARTICLE III

"Five years after the entry into force of this Treaty, a conference of Parties shall be held at Geneva, Switzerland, in order to review the operation of this Treaty with a view to assuring that the purposes of the preamble and the provisions of the Treaty are being realized. Such review shall take into account any relevant technological developments in order to determine whether the definition in Article II should be amended.

"ARTICLE IV

"1. Any Party may propose an amendment to this Treaty. The text of any proposed amendment shall be submitted to the Depositary Governments which shall circulate it to all Parties to this Treaty. Thereafter, if requested to do so by one-third or more of the Parties, the Depositary Governments shall convene a conference to which they shall invite all the Parties, to consider such amendment.

"2. Any amendment to this Treaty shall be approved by a majority of the votes of all the Parties to this Treaty. The amendment shall enter into force for all Parties upon the deposit of instruments of ratification by a majority of all the Parties.

"ARTICLE V

"1. This Treaty shall be of unlimited duration.

"2. Each Party shall in exercising its national sovereignty have the right to withdraw from the Treaty if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other Parties to the Treaty three months in advance.

"ARTICLE VI

"1. This Treaty shall be open to all States for signature. Any State which does not sign this Treaty before its entry into force in accordance with paragraph 3 of this Article may accede to it at any time.

"2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, , and which are hereby designated the Depositary Governments.

"3. This Treaty shall enter into force after its ratification by the States, the Governments of which are designated Depositaries of the Treaty.

"4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

"5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification of and accession to this Treaty, the date of its entry into force, and the date of receipt of any requests for conferences or other notices.

"6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations."

DEPARTMENT OF STATE,
Washington, D.C., May 15, 1972.

Hon. J. W. FULBRIGHT,
Chairman, Committee on Foreign Relations,
U.S. Senate.

DEAR MR. CHAIRMAN: The Secretary has asked me to reply to your letter of March 21, 1972, requesting coordinated Executive Branch comments on S. Res. 281. This resolution would express the sense of the Senate that the United States Government should seek the agreement of other governments to a treaty providing for the complete cessation of any research, experimentation and use of any environmental or geophysical modification activity as a weapon of war. The text of a draft treaty is incorporated in the resolution.

As recently as March 16, 1972, the President in his message to the Congress on science and technology has stressed the potential importance of our earthquake and hurricane research efforts in reducing loss of life and property from natural disasters. This emphasis is consistent with the view expressed in the resolution that such activities may contribute to human betterment.

As the Committee is aware, the Executive Branch has conducted a preliminary inter-agency review of questions related to international aspects of weather modification. However, this review did not deal fully with several aspects of S. Res. 281 and questions that arose relating to other important aspects still remain unanswered. Therefore, the Department is not in a position to comment on the substance of S. Res. 281 and recommends that the resolution not be adopted at this time.

The Office of Management and Budget advises that from the standpoint of the Administration's program, there is no objection to the submission of this report.

Sincerely yours,

DAVID M. ABSHIRE,
Assistant Secretary for Congressional Relations.

REPORTS OF U.S. WEATHER MODIFICATION OPERATIONS IN SOUTHEAST ASIA

In addition, there have been unconfirmed and unofficial reports that the United States has or is attempting to manipulate weather in

Southeast Asia as a weapon of warfare. These reports have served to deepen my own concern.

My own concern started before these reports, I may add.

As chairman of this subcommittee, I wrote the Defense Department on September 23, 1971, requesting specific information about such activities. That is more than 9 months ago.

After 4 months of correspondence, which I made public on the floor of the Senate on January 26 of this year, the Defense Department declined to answer my questions on the basis that such replies would threaten the national security.

This response, coupled with the revelations made in recent articles by several investigative reporters, leaves no doubt in my mind that the United States has indeed been conducting weather modification operations in Southeast Asia.

This is a situation which I find extremely distressing. Rainmaking as a weapon of war can only lead to the development of vastly more dangerous environmental techniques whose consequences may be unknown and may cause irreparable damage to our global environment. This is why the United States must move quickly to ban all environmental or geophysical modification techniques from the arsenals of war.

The United States has been preeminent in the field of meteorology and has played a leading role in the development of international scientific collaboration in the area of long-range weather forecasting.

The military use of weather modification techniques could seriously jeopardize these peaceful scientific programs and could undermine all future international cooperation on environmental matters.

WHAT UNITED STATES SHOULD DO

Therefore, it is imperative that the United States enunciate a national policy on this subject, which would dedicate all environmental and geophysical modification efforts to peaceful purposes. Instead of its official silence and actions condoning a gradual drift into environmental warfare, the administration should actively explore both the advantages of a renunciation of such operations and the possible benefits stemming from an initiative for a multilateral "no first use" agreement. In the absence of such a ban, the way has been left open to the planning, development, and prosecution of deliberate environmental or geophysical warfare.

The United States, as Cochairman of the United Nations Disarmament Committee, should take the initiative in framing and introducing to the committee a broad treaty imposing a prohibition on all forms of geophysical and environmental warfare. By these actions the United States would enhance world order and stability, and encourage a greater sense of openness in the application of new technologies to environmental problems of global concern.

At this point I would like to have inserted into the record various newspaper articles from the Providence, R.I., Journal, from the New York Times, and from the Washington Post.

(The articles referred to follow:)

[From the Providence (Rhode Island) Journal, June 26, 1972]

Pell Feels U.S. Wages Weather Warfare

(By Bruce DeSilva)

Washington.—The Pentagon has the power to change the weather and already may have used that power to kill and destroy in Southeast Asia.

"I strongly believe clouds have been seeded in Southeast Asia for military reasons. There is very little doubt in my mind," Sen. Claiborne Pell said during an interview in his Washington office last week.

David Keaney, a member of the professional staff of the Senate foreign relations committee, is less cautious. "I have no doubt at all," he said.

Senator Pell said he believes the military has been seeding clouds, perhaps beginning as early as 1966, to clear them away from bombing targets in North Vietnam. He said he also believes seeding with other chemicals has produced torrential rains. The rains have washed out portions of the Ho Chi Minh Trail impeding the infiltration of supplies and men from North to South Vietnam, and caused floods which killed thousands, he said.

Defense Department spokesmen have admitted that they have the capability to drastically increase rainfall, but in a sharp exchange of letters with Senator Pell and in a sharp exchange in a Senate foreign relations committee hearing with Sen. J. William Fulbright of Arkansas, they have refused to confirm, but carefully avoided denying, that such activities are under way in Southeast Asia.

Beginning in June of last year and lasting well into the normally dry season in the fall, North Vietnam was devastated by heavy rains, typhoons and floods.

According to reports by Pierre Darcourt, a French journalist, the heavy rains triggered mud slides, washed away or weakened roads and breached dikes.

The Associated Press reported that flooding destroyed 10 percent of the country's rice crop and killed thousands.

North Vietnamese Premier Pham Van Dong, the Christian Science Monitor reported, said water levels in the entire Red River and Thai Binh River system rose to "unprecedented levels." He called the flooding the "worst disaster since the beginning of the war."

An act of God? Perhaps.

But Senator Pell said he believes the disaster was merely the most successful of Pentagon rainmaking efforts in the region.

The best evidence that the Pentagon is altering the weather is provided in brief remarks in the Pentagon Papers. The significance of the remarks apparently went largely unnoticed during the furor of other sensational disclosures in the documents.

According to the Gravel edition of the papers, Volume 4, Page 421, the Joint Chiefs of Staff presented President Lyndon B. Johnson with a memo in 1967 suggesting that modifying the weather in the region might be one way of widening the war without creating dissent at home.

The memo stated in part:

"Laos Operations—Continue as at present plus Operation Pop Eye to reduce trafficability along infiltration routes. Authority/Policy Changes—Authorization required to implement operational phase of weather modification process previously successful tested and evaluated in some area."

Later that year, the President was presented with a list of escalation proposals, the Papers indicate. The list included the following item:

"Cause interdicting rains in or near Laos."

Other evidence concerning the rainmaking efforts are circumstantial.

In March of last year, Jack Anderson, a nationally syndicated columnist, claimed in his column that the Air Force has been seeding clouds over Laos and Cambodia since 1967. He said the project went by the code name of "Intermediary-Compatriot."

Unlike other Anderson columns, such as the one on the ITT memo or the disclosure of a secret U.S. posture during the India-Pakistan war, this column went largely unnoticed nationally.

Last Sept. 23, Senator Pell sent a letter to Rady Johnson, assistant secretary of defense for legislative affairs, inquiring about "the Air Force weather modification activities against the North Vietnamese."

The letter, and all subsequent communication, was made public by the senator and was inserted in the Jan. 26 Congressional Record.

The letter asked the following questions:

"1. What are the objectives of the project known by the code name 'Intermediary-Compatriot'?

"2. How long has this project been in existence? Would you provide a rather detailed description of this project?

"3. In what specific countries is this project conducted?

"4. What amounts have been spent on this project over the last three years?

"5. Is the Department conducting any similar offense-oriented weather modification programs? If so, what are the names of these projects and where are they being conducted?"

ANOTHER LETTER

The following day, Mr. Johnson replied, saying the questions had been referred to the director of defense research and engineering.

After waiting for a response for two weeks, Senator Pell sent another letter to Mr. Johnson, again asking for a reply to his earlier questions.

On Nov. 23, Mr. Johnson sent the senator a lengthy reply.

The reply stated in part that "the possibilities inherent in weather modification techniques to support military operations have been the subject of discussion for more than 20 years. For a number of these years, the Department of Defense has been conducting several modest research and development programs relating to various forms of weather modification."

In the letter, Mr. Johnson stated that research has been undertaken for "the suppression of hail and lightning (to reduce damage to military property and equipment and to increase safety of operations) and the dissipation of fog at airports and within harbors (to enhance operations of safety of aircraft and ships.)"

"RELATIVELY SIMPLE"

The letter added that "One example of fruitful field research has been the investigation of precipitation augmentation. . . . When the proper meteorological conditions prevail (that is, when clouds capable of producing natural rain exist) it is a relatively simple matter to increase the amount of rain which will fall. The amount of increase is frequently of the order of 30 to 50 per cent."

Mr. Keaney said some scientists have told him the increase could actually be ten or 20 times that. However, he noted, a 50 per cent increase in the monsoon rains of Southeast Asia can have a tremendous impact.

Mr. Johnson's letter noted that in 1969, the Department of Defense, at the request of the Philippines, conducted a six-month rainmaking project on the Philippine Islands to relieve a drought. "The Philippine government considered the undertaking so successful that they have subsequently taken steps to acquire an independent capability," the letter added.

"I trust," the letter closed, "that the foregoing information will be helpful to you and regret the delay in responding to your inquiry."

QUESTIONS UNANSWERED

But the letter did not answer a single one of Senator Pell's questions.

Senator Pell sent a letter to Defense Secretary Melvin Laird on Dec. 3 stating his dissatisfaction with Mr. Johnson's letter and requesting "a written response to the specific questions."

Mr. Laird referred the letter to John S. Foster Jr., director of defense research and engineering, who sent a written reply to Senator Pell on Dec. 16.

"Certain aspects of our work in this area are classified," Mr. Foster's letter said. "Recognizing that the Congress is concerned with the question of the military application of weather modification technology, I have, at the direction of Secretary Laird, seen to it that the chairmen of the committees of Congress with primary responsibility for this department's operations have been completely informed regarding the details of all classified weather modification undertakings by the department.

"RESPECTFULLY DECLINE"

"However, since the information to which I refer has a definite relationship to national security and is classified as a result, I find it necessary to respectfully decline to make any further disclosures of the details of these activities at this time."

Senator Pell said he understood the letter to mean that only Sen. John Stennis, D-Miss., and Rep. F. Edward Hébert, D-La., the chairman of the Senate and House armed services committees, had been briefed on the matter.

The briefings were confidential and make it impossible for those two legislators to discuss the matter even if they want to.

Senator Pell said he has been offered a classified briefing but has declined to accept it because it would limit his ability to ask Defense Department officials probing questions about the project at future Senate hearings and limit his freedom to speak out on the subject.

LARGELY UNNOTICED

When Mr. Laird appeared before the foreign relations committee in April to testify concerning renewed bombing of the North, Senator Pell and Senator Fulbright questioned him briefly on weather modification. The exchange went largely unnoticed in the press.

Senator Pell asked Mr. Laird if the United States had engaged in rainmaking activities "for military reasons in Southeast Asia."

Mr. Laird replied, "I don't discuss the operating authority that we go forward with as far as Southeast Asia specifically, but I would be glad to discuss with you the techniques that have been used outside the battle zone."

Senator Fulbright asked, "Why do you decline to discuss weather control activities in North Vietnam, yet you freely discuss B–52 flights over North Vietnam?"

After a brief exchange between Mr. Laird and Senator Fulbright, Mr. Laird said, "We have never engaged in the type of activity over North Vietnam."

Senator Pell said last week that Mr. Laird carefully limited his response to "activity over North Vietnam." It would be expected that clouds would be seeded over Laos or Cambodia or over the Tonkin Gulf, depending on the time of year, rather than over North Vietnam, Senator Pell added.

The senator said the Defense Department has been "extremely sensitive" to questioning about weather modification and that information about it has been difficult to get.

Such an operation is easy to keep secret, because three men in a small plane are all that is needed to carry it out. Large numbers of men need not be involved, the senator said.

Senator Pell said one indication that the Pentagon is involved in weather modification over Vietnam is the United States' decision to torpedo a resolution on weather modification at the United Nations Environmental Conference in Stockholm earlier this month.

A resolution on the question required that before taking any action that might have an effect on the climate, a government should evaluate the change that could occur and disseminate its findings.

"IT GIVES THEM AN OUT"

The United States succeeded in amending the agreement to say that information will be disseminated "to the maximum extent feasible."

"It gives them an out. They can say that dissemination is not feasible for security reasons," Senator Pell said.

Fearful that the Pentagon's tinkering with natural phenomenon may not be limited to make rain, Senator Pell has prepared a draft of a treaty that would ban all weather and climate modification activities as weapons of war.

On March 17, he introduced a resolution in the Senate stating that it is "the sense of the Senate" that such a treaty be negotiated. Among its 14 sponsors are Senators Edward M. Kennedy of Massachusetts, George McGovern of South Dakota, and Hubert H. Humphrey, Minnesota.

"When I proposed the seabed treaty (banning nuclear arms from the ocean floors), a string of ABM's along the Atlantic Ridge and creepycrawlers (tank-like weapons that would crawl along the ocean floor) were on the drawing board at the Pentagon." Senator Pell said.

CAN LEAD TO DISASTER

Weather modification is also "a weapon that can lead to disaster," he said.

If the Pentagon can make rain, is it also trying to develop ways to divert typhoons to the shores of other nations or cause earthquakes? the senator wondered.

Without a treaty banning such activities, an inland nation could melt the antarctic ice (which can be easily done by sprinkling soot on it according to scientists) and raise the level of the sea by 300 feet, he said.

Senator Pell referred to an article by Gordon J. F. McDonald, a member of the Council for Environmental Quality in the Nixon administration, which was printed in 1968 in a book titled "Unless Peace Comes."

In the article, Mr. McDonald said weather and climate modification "might be carried out covertly since nature's great irregularity permits storms, flooding, earthquakes, and tidal waves to be viewed as unusual but not unexpected."

OR EVEN KNOWN

"Such a secret war will never be declared or ever known by the affected population. It could go on for years with only the security forces involved, being aware of it," the article stated.

"These are the kinds of weapons I don't want to see developed," Senator Pell said, adding that the Soviet Union is doing research on weather and climate modification.

Senator Pell said he plans hearings on his resolution and treaty late next month or in August.

He said he expects to have "some exciting witnesses" for the hearings and hopes the hearings will "flush out" the truth concerning Pentagon weather modification activities.

[From the Washington Post, July 2, 1972]

WEATHER WAR: A GATHERING STORM

(By Victor Cohn)

Technological America, that accomplished laser-radar-electronic warrior, has been learning to use still another remote-control weapon: control of the weather for military purposes.

Indochina—by the evidence of a long-ignored passage in the Pentagon Papers—has been a test battleground, the site of purposeful rain-making along the Ho Chi Minh trails. Some accusers, going further, hold American rain-makers responsible for the flood disasters that struck North Vietnam last year.

How much there is past a hard kernel of truth behind an array of increasingly serious accusations is unclear. Yet the very possibility that there has been serious weather war—as well as the emerging fact that the Pentagon has been systematically developing a rain-making capability—is enough to chill many scientists.

These scientists include fearful prophets who warn of future "geophysical warfare"—wars waged by adjusting, changing, modifying and ultimately despoiling the air, water and earth.

They also include a growing number of weather-modifiers, scientists interested in the peaceful uses of seeding clouds, modifying hurricanes or preventing hail to help farmers and everyone else.

OPERATION POP EYE

The term "seeding" simply means making the proper clouds yield rain, or destructive force, by bombarding them with silver iodide particles. The particles act as condensation nuclei around which moisture can form. The would-be cloud engineers want to develop such programs through international cooperation, because both weather and weather modification ignore borders.

Weather modification, these men believe, is on the verge of huge advances, and needs only a period of concentrated research, in a framework of interstate and international rules.

But "if it turns out that the U.S. has militaristic uses for weather modification," one weather scientist maintains, "international weather programs would drop dead."

A prominent White House scientist, Dr. Gordon J. F. MacDonald, geophysicist-member of the President's three-man Council on Environmental Quality, is among those who believe it is important for nations to agree not to wage weather war—"before," as he put it, "it becomes a reality."

Sen. Claiborne Pell (D–R.I.) is prominent among members of Congress who believe it has become a reality. "There is very little doubt in my mind," he says. Rep. Gilbert Gude (R–Md.) states: "There's no doubt in my mind that it's going on in Vietnam."

"I think there's no doubt rain-making was used in Laos on the trail," says a Senate committee aide well versed in defense affairs. "And I think there's little doubt that it has been used fairly recently; that is, in 1971."

Such use, in 1971 or otherwise, may have been only sporadic, several sources believe. "Otherwise," said one, "a lot more people would have known about it long ago."

It is a "successful" pre-1967 use, sometime in the years of Vietnam escalation, possibly in 1966, that is documented in the "Senator Gravel" edition of the Pentagon Papers. In late February, 1967, this document discloses the Joint Chiefs of Staff prepared a list of "alternative strategies" for President Johnson.

One, titled "Laos Operations," read:

"Continue as at present plus Operation Pop Eye to reduce trafficability along infiltration routes . . . Authorization required to implement operational phase of *weather modification process previously successfully tested and evaluated in same area*." (Italic added.)

In 1967—according to columnist Jack Anderson, who published the first allegation of Indochina rain-making—U.S. forces started secret Project Intermediary Compatriot "to hamper enemy logistics . . . (with) claimed success in creating man-made cloudbursts . . . (and) flooding conditions" along the Ho Chi Minh trails, "making them impassable."

"CLASSIFIED" WORK

Senator Pell, most persistently, and Rep. Gude and Sen. Alan Cranston (D-Calif.), on behalf of Members of Congress for Peace Through Law, have showered the Pentagon with inquiries since Anderson published his charges in March, 1971. Defense Secretary Melvin Laird and Director of Defense Research and Engineering John Foster have repeatedly replied (to quote Laird): "Some aspects of our work in this area have a definite relationship to national security and are classified accordingly."

In April, Senate Foreign Relations Committee Chairman J. William Fulbright (D-Ark.), pressed further, asking Laird: "Why do you decline to discuss weather control activities in North Vietnam, yet you freely discuss B-52 flights over Vietnam?" Laird replied blandly, "We have never engaged in that type of activity over North Vietnam."

Fulbright failed to go on to ask Laird about Laos or Cambodia or the Gulf of Tonkin, where some Vietnam weather originates. "He just didn't follow up on that question," one of his staff explains. "He was trying to cover a whole range of things."

The Defense Department freely reports that it has "field capabilities" for making rain. It used them in the Philippines in 1969, in a six-month "precipitation augmentation project" at the Philippines request; in India in 1967, at a similar invitation; over Okinawa and Midway islands, and in June, July, and August 1971, over drought-stricken Texas, at the urgent request of Gov. Preston Smith.

Pierre Saint-Amand, head of earth and planetary sciences for the Naval Ordnance Laboratory at China Lake, Calif., led the Philippine Project, which that government considered highly successful. The India and Midway tries failed for lack of suitable clouds. But the Texas effort, by Air Force crews, was "remarkably successful," in Saint-Amand's view.

Navy rain-makers are currently involved in two long-range California programs—one over the Pacific off Santa Barbara, an attempt to increase rainfall over a national forest; the other over the Central Sierras to try to increase the snow-pack for electric utilities that depend on water power.

Air Force weather modifying is done by Air Weather Service, working out of Scott Field, East St. Louis, Ill., with participation by the Environmental Technology Applications Center at Suitland, Md. Operations over Indochina are flown out of Udorn Air Force Base, Thailand, says a Senate source.

"None of the weather research work in the entire DOD is classified," Saint-Amand adds—the word *research* should be noted here. "Our labs are open to anyone who wants to come and see what we're doing." Chief Scientist John N. Howard of the Air Force's Cambridge Research Laboratories at Bedford, Mass., made a similar statement. The Defense Department's Advanced Research Projects Agency (ARPA) likewise reports conducting only unclassified research.

An ARPA study called Nile Blue has been cited by some of the military's accusers as prime evidence of nefarious DOD rainmaking. Actually, Nile Blue is a study by computer of how purposeful or accidental man-made changes might

affect the globe's year-to-year climate rather than the day-to-day conditions called weather.

Nile Blue has been funded this year at $2.5 million but will rise to $3.1 million in fiscal 1973, with use of a new super-computer, Illiac IV, designed at the University of Illinois and now being installed at Ames Research Center, Moffett Field, Calif.

Defending the project, ARPA Director Stephen J. Lukasik told the Senate Appropriations Committee in March: "Since it now appears highly probable that major world powers have the ability to create modifications of climate that might be seriously detrimental to the security of this country, Nile Blue . . . was established in FY 70 to achieve a U.S. capability to (1) evaluate all consequences of a variety of possible actions . . . (2) detect trends in the global circulation which foretell changes . . . and (3) determine if possible, means to counter potentially deleterious climatic changes . . ."

"What this means," Lukasik explains, "is learning how much you have to tickle the atmosphere to perturb the earth's climate. I guess we'd call it a threat assessment."

A VISION OF ECOCIDE

How might such changes be made by one country desiring to harm another?

The highly respected Dr. MacDonald, who will leave the White House soon to teach at Dartmouth, wrote a 1968 warning against geophysical warfare, titled "How to Wreck the Environment." On weather war in Indochina, he now says only, "I wouldn't know about that." But melting the Arctic ice cap by some means, he conjectured in 1968, might be one future way in which a land-locked equatorial country could flood the world's coastal cities while insuring itself a temporate climate with abundant rainfall.

"As economic competition among many advanced nations heightens," he warned, "it may be to a country's advantage to ensure a peaceful natural environment for itself and a disturbed environment for its competitors. Operations . . . might be carried out covertly . . . The years of drought and storm would be attributed to unkindly nature and only after a nation were thoroughly drained would an armed takeover be attempted."

Far-fetched? Short-term rain-making—which MacDonald in 1968 called only a "future" military possibility—already seems an easier, if capricious, weapon.

"When the proper meteorological conditions prevail (that is, when clouds capable of producing natural rain exist)," Laird told Sen. Pell in a November letter, "it is a relatively simple matter to increase the amount of rain which will fall. The amount of increase is frequently of the order of 30 to 50 per cent."

Laird carefully added: "Massive downpours have not been produced, and theoretical knowledge at hand indicates that this will probably always be the case." This, if oblique, seemed to quarrel with the allegations that the 1971 North Vietnam floods had been produced by the Pentagon. Pell, however, maintains that U.S. cloud-seeding produced the floods, which he says killed thousands.

"IT IS ENTIRELY POSSIBLE"

Robert M. White, the nation's chief weather man as director of the Commerce Department's National Oceanographic and Atmospheric Administration (NOAA), declined to discuss military matters in an interview. But to the question, "Could cloud seeding cause flooding?" he—unlike Laird—said, "Yes, it is entirely possible to get heavy rains out of certain clouds."

"In the past decade," White added, "there has been a considerable change of view in the scientific community on weather modification. I think most knowledgeable people would agree that we have primitive capabilities for modifying certain weather patterns. And it is reasonable now to look to possible development of more sophisticated ones."

Among patterns that can "predictably" be modified, he said, are: cold fog (which can be cleared from airfields); cumulus clouds (most common in the tropics—"In Florida," White said, "we have been able almost at will to make them grow explosively"); orographic clouds (moist air moving up over mountains—"At the right temperature you can begin thinking of milking them for water") and hailstorms (which can often be suppressed, according to recent claims by the Russians, who fire silver iodide into them from rockets and artillery).

Beyond these, there are storms like hurricanes—a Hurricane Agnes, for example—which cannot yet be reliably suppressed, "but for which we have some encouraging results," in White's view.

All in all, he sums up, "We're beginning to move from a situation where everything that happens in the atmosphere is an act of God to where some things are an act of man."

THE MORAL ISSUE

What perturbs many scientists is the morality of using such "acts of man" for military purposes.

The Navy's Saint-Amand emphatically does not see turning weather into a weapon as something inherently evil. "If you estimate the amount of damage done by impeding someone's transportation versus blowing or burning them up, I don't think it is so immoral," he told Science magazine.

Most scientists, left-wing and establishment, seem to disagree.

The Science for Vietnam, Chicago Collective—a radical anti-war group of scientists and students who first spotted the passage in the Pentagon Papers—charges: "The U.S. government has embarked on a totally new and insidious form of warfare . . . (that) could disrupt the economy and social structure of a small country; it could create famine . . ."

University of Connecticut Graduate Dean Thomas Malone, chairman of the National Academy of Sciences' Weather Modification Panel, likewise says: "I'm opposed to it." He urges a treaty that would not merely ban weather war but go on to encourage international weather modification "in a positive way." A 1971 Academy study urged the United States to sponsor a United Nations resolution dedicating all weather modifying to peace.

Unless nations do this, Malone told Science, "we will face horrendous political problems—putting the genie back in the bottle."

Pell argues that present military activities "could very well lead to another international arms race." "The use of rain-making as a weapon of war can only lead to the development of vastly more dangerous environmental techniques," he says. "We must move quickly to place weather, climate and geophysical modification off limits."

Joined by 13 colleagues (McGovern, Humphrey, Case, Cooper, Cranston, Hart, Hughes, Javits, Kennedy, Mondale, Nelson, Tunney and Williams), he has proposed a Senate resolution urging that the United States seek a treaty to bar both weather war and research into it. As chairman of the Senate Foreign Relations Committee's international environment subcommittee, Pell will try to smoke Laird out further at upcoming hearings, perhaps this month.

LACK OF RESPONSE

The administration, too, may be considering the subject. But how seriously it is doing so is unsure.

The Pentagon's Foster told Gude that the National Security Council Under Secretaries' Committee "at the request of Dr. Kissinger is currently meeting to formulate a definitive national policy. Presumably this policy, when completed, will be announced to the nation in some appropriate fashion."

The NSC unit involved is headed by Herman Pollock, the State Department's director of international scientific affairs. He reports that it has considered only peaceful weather-making, not military.

Pell is undiscouraged by lack of administration response so far to the pleas that it support his proposed treaty, or that the President declare that the United States will never be first to wage weather war.

"I remember what happened five years ago when I first introduced a draft treaty to ban nuclear weapons from the seabed," he says. "I got rather unreal executive branch comment, just as we're getting now. But I knew very well that a strip of missiles along the Atlantic ridge and 'creepy crawlers'—tank-like underwater missile carriers—were on the drawing board at the Pentagon.

"I see the same process now. I think that given a few years, we'll get some sort of treaty here, too."

Of all fields of science, Dean Malone has said, none has produced more world cooperation than meteorology. "What a tragic reversal it would be if we started using our knowledge to beat one another over the head."

[From the New York Times, July 3, 1972]

Scientists are Critical of Rainmaking in War

(By John Noble Wilford)

After years of rainmaking experimentation, scientists are still not sure they understand the short-term effects of cloud-seeding, much less the possible long-term impact on the ecology of a region or the entire world.

This uncertainty has led to increasing concern among scientists over the use of weather modification as an instrument of warfare.

Dr. Matthew Meselson, professor of biology at Harvard University, was quoted in the June 16 issue of the magazine Science as saying:

"It is obvious that weather modification used as a weapon of war has the potential for causing large-scale and quite possibly uncontrollable and unpredictable destruction. Furthermore, such destruction might well have a far greater impact on civilians than on combatants. This would be especially true in areas where subsistence agriculture is practiced, in food-deficit areas, and in areas subject to flooding."

ISSUE RAISED RECENTLY

The issue has also been raised in recent months by the National Academy of Sciences, on the floor of the United States Senate and at the international environmental meeting at Stockholm last month.

Recognizing the many potential problems, the national academy issued a statement last year urging the Nixon Administration to sponsor a United Nations resolution "dedicating all weather modification efforts to peaceful purposes and establishing, preferably within the framework of international nongovernmental scientific organizations, an advisory mechanism for consideration of weather-modification problems of potential international concern."

Senator Claiborne Pell, Democrat of Rhode Island, and 13 other Senators recently filed a resolution calling on the United States to join in a treaty outlawing "any use of any environmental or geophysical modification activity as a weapon of war, or the carrying out of any research or experimentation with respect thereto."

But, during the Stockholm conference, the United States delegation was instrumental in inserting a weakening clause in a recommendation calling for all governments to "carefully evaluate the likelihood and magnitude of climactic effects" from weather modification and to disseminate their findings.

U.S. SPONSORS STUDY

The weakening clause included the words, "to the maximum extent feasible." Officials later acknowledged that possible military use of weather modification was the basis for the amendment.

However, the Department of Defense's Advanced Research Projects Agency is sponsoring research to determine how much and what kind of tinkering with the atmosphere is required to disturb the climate on a global scale—an indication that the Pentagon is not sure of the ecological impact of weather warfare.

The Defense Department acknowledges that it conducted "precipitation augmentation projects" in the Philippines in 1969, in India in 1967, over Okinawa and the Mid islands in 1971 and in Texas last summer—all at the request of the governments involved.

The results were mixed—success in the Philippines and Texas, but not elsewhere. Other tests over the years have failed to increase rainfall, or else failed to convince meteorologists that the rains would not have fallen without human intervention.

But tests in Florida, in 1968 and 1970, led civilian scientists to conclude that clouds seeded with silver iodide crystals rained more than three times as much as unseeded clouds. The experiment, conducted by the National Oceanic and Atmospheric Administration, produced "explosive" growth of rain clouds.

CONTROVERSY REMAINS

While conceding that "there's still quite a bit of controversy over whether your seeding caused rain or not," Ferguson Hall of the agency's Office of Environmental Modification said yesterday in a telephone interview from his Rockville, Md., office: "We seem to be on the verge of having convinced ourselves rainmaking will work in certain cases."

Rainmaking research primarily involves experiments in seeding clouds with silver iodide, dry ice, common salt and other chemicals that can act as condensation nuclei. The Federal Government is spending about $20-million annually on weather-modification research.

There are two types of clouds, warm and cold, and thus two processes by which seeding is believed to trigger rainfall.

In 1946, the first American experiments in cloud seeding, by Vincent J. Schaefer of the General Electric Research Laboratory in Schenectady, were aimed at supercooled clouds. From an airplane, Mr. Schaefer dropped three pounds of dry ice (frozen carbon dioxide) into clouds to create billions of glistening ice crystals.

MOISTURE TO ICE

Dry ice—or silver iodide, which is more commonly used today—turns moisture in the clouds to ice crystals that grow larger and larger until they are heavy enough to fall as either rain or snow.

Silver iodide is ordinarily used as the seeding agent because its crystals are similar to those of ice and it is more effective in causing supercooled water drops to freeze.

In warm clouds, salt or silver iodide particles can cause moisture to coalesce into water droplets large enough to fall as rain. This would be the type of experiments that could be effective in tropical or semitropical areas, such as Southeast Asia.

The type of seeding agent that could cause a highly acidic rainfall, as reported in Southeast Asia, has not been disclosed. Civilian scientists are loathe to discuss the possibility, except to note that the method has a name—hygroscopic seeding.

Most cloud-seeding operations are conducted by airplane—the C–130 in Vietnam. But small rockets can also be used to deliver the seeding agent.

[From the New York Times, July 3, 1972]

RAINMAKING IS USED AS WEAPON BY U.S.—CLOUD-SEEDING IN INDOCHINA IS SAID TO BE AIMED AT HINDERING TROOP MOVEMENTS AND SUPPRESSING ANTIAIRCRAFT FIRE

(By Seymour M. Hersh)

WASHINGTON, July 2.—The United States has been secretly seeding clouds over North Vietnam, Laos and South Vietnam to increase and control the rainfall for military purposes.

Government sources, both civilian and military, said during an extensive series of interviews that the Air Force cloud-seeding program has been aimed most recently at hindering movement of North Vietnamese troops and equipment and suppressing enemy antiaircraft missile fire.

The disclosure confirmed growing speculation in Congressional and scientific circles about the use of weather modification in Southeast Asia. Despite years of experiments with rainmaking in the United States and elsewhere, scientists are not sure they understand its long-term effect on the ecology of a region.

SOME OPPOSED PROGRAM

The weather manipulation in Indochina, which was first tried in South Vietnam in 1963, is the first confirmed use of meteorological warfare. Although it is not prohibited by any international conventions on warfare, artificial rainmaking has been strenuously opposed by some State Department officials.

It could not be determined whether the operations were being conducted in connection with the current North Vietnamese offensive or the renewed American bombing of the North.

EFFECTIVENESS DOUBTED

Beginning in 1967, some State Department officials protested that the United States, by deliberately altering the natural rainfall in parts of Indochina, was taking environmental risks of unknown proportions. But many advocates of the operation have found little wrong with using weather modification as a military weapon.

"What's worse," one official asked, "dropping bombs or rain?"

All of the officials interviewed said that the United States did not have the capability to cause heavy floods during the summer in the northern parts of North Vietnam, where serious floods occurred last year.

Officially, the White House and State Department declined comment on the use of meteorological warfare. "This is one of those things where no one is going to say anything," one official said.

Most officials interviewed agreed that the seeding had accomplished one of its main objectives—muddying roads and flooding lines of communication. But there were also many military and Government officials who expressed doubt that the project had caused any dramatic results.

The sources, without providing details, also said that a method had been developed for treating clouds with a chemical that eventually produced an acidic rainfall capable of fouling the operation of North Vietnamese radar equipment used for directing surface-to-air missiles.

In addition to hampering SAM missiles and delaying North Vietnamese infiltration, the rainmaking program had the following purposes:

—Providing rain and cloud cover for infiltration of South Vietnamese commando and intelligence teams into North Vietnam.

—Serving as a "spoiler" for North Vietnamese attacks and raids in South Vietnam.

—Altering or tailoring the rain patterns over North Vietnam and Laos to aid United States bombing missions.

—Diverting North Vietnamese men and material from military operations to keep muddied roads and lines of communication in operation.

KEYED TO MONSOON

The cloud-seeding operations necessarily were keyed to the two main monsoon seasons that affect Laos and Vietnam. "It was just trying to add on to something that you already got," one officer said.

Military sources said that one main goal was to increase the duration of the southwest monsoon, which spawns high-rising cumulus clouds—those most susceptible to cloud-seeding—over the panhandle areas of Laos and North Vietnam from May to early October. The longer rainy season thus would give the Air Force more opportunity to trigger rainstorms.

"We were trying to arrange the weather pattern to suit our convenience," said one former Government official who had detailed knowledge of the operation.

According to interviews, the Central Intelligence Agency initiated the use of cloud-seeding over Hue, in the northen part of South Vietnam. "We first used that stuff in about August of 1963," one former C.I.A. agent said, "when the Diem regime was having all that trouble with the Buddhists."

"They would just stand around during demonstrations when the police threw tear gas at them, but we noticed that when the rains came they wouldn't stay on," the former agent said.

"The agency got an Air America Beechcraft and had it rigged up with silver iodide," he said. "There was another demonstration and we seeded the area. It rained."

A similar cloud-seeding was carried out by C.I.A. aircraft in Saigon at least once during the summer of 1964, the former agent said.

EXPANDED TO TRAIL

The intelligence agency expanded its cloud-seeding activities to the Ho Chi Minh supply trail in Laos sometime in the middle nineteen-sixties, a number of Government sources said. By 1967, the Air Force had become involved although, as one former Government official said, "the agency was calling all the shots."

"I always assumed the agency had a mandate from the White House to do it," he added.

A number of former CIA and high-ranking Johnson Administration officials depicted the operations along the trail as experimental.

The art had not yet advanced to the point where it was possible to predict the results of a seeding operation with any degree of confidence, one Government official said. "We used to go out flying around and looking for a certain cloud formation," the official said. "And we made a lot of mistakes. Once we dumped seven inches of rain in two hours on one of our Special Forces camps."

Despite the professed skepticism on the part of some members of the Johnson Administration, military men apparently took the weather modification program much more seriously.

According to a document contained in the Pentagon papers, the Defense Department's secret history of the war, weather modification was one of seven basic options for stepping up the war that were presented on request by the Joint Chiefs of Staff to the White House in late February, 1967.

The document described the weather program over Laos—officially known as Operation Pop-Eye—as an attempt "to reduce trafficability along infiltration routes."

It said that Presidential authorization was "required to implement operational phase of weather modification process previously successfully tested and evaluated in same area." The brief summary concluded by stating that "risk of compromise is minimal."

A similar option was cited in another 1967 working document published in the Pentagon papers. Neither attracted any immediate public attention.

The Laos cloud-seeding operations did provoke, however, a lengthy and bitter, albeit secret, dispute inside the Johnson Administration in 1967. A team of State Department attorneys and officials protested that the use of cloud-seeding was a dangerous precedent for the United States.

"I felt that the military and agency hadn't analyzed it to determine if it was in our interest," one official who was involved in the dispute said. He also was concerned over the rigid secrecy of the project, he said, "although it might have been all right to keep it secret if you did it once and didn't want the precedent to become known."

The general feeling was summarized by one former State Department official who said he was concerned that the rainmaking "might violate what we considered the general rule of thumb for an illegal weapon of war—something that would cause unusual suffering or disproportionate damage." There was also concern he added, because of the unknown ecological risks.

A Nixon Administration official said that he believed the first use of weather modification over North Vietnam took place in late 1968 or early 1969 when rain was increased in an attempt to hamper the ability of antiaircraft missiles to hit American jets in the panhandle region near the Laotian border.

Over the next two years, this official added, "it seemed to get more important—the reports were coming more frequently."

It could not be learned how many specific missions were carried out in any year. One well-informed source said that Navy scientists were responsible for developing a new kind of chemical agent effective in the warm stratus clouds that often shielded many key antiaircraft sites in northern parts of North Vietnam.

The chemical, he said, "produced a rain that had an acidic quality to it and it would foul up mechanical equipment—like radars, trucks and tanks."

"This wasn't originally in our planning," the official added, "it was a refinement."

Apparently, many Air Force cloud-seeding missions were conducted over North Vietnam and Laos simply to confuse or "attenuate"—a word used by many military men—the radar equipment that controls antiaircraft missiles. The planes used for such operations, C–130's, must fly at relatively slow speeds and at altitudes no greater than 22,000 feet to disperse the rainmaking chemicals effectively.

A number of officials confirmed that cloud-seeding had been widely used in South Vietnam, particularly in the north along the Laos border. "We tried to use it in connection with air and ground operations," a military officer explained.

One Government official explained more explicitly that "if you were expecting a raid from their side, you would try to control the weather to make it more difficult." This official estimated that more than half of the actual cloud-seeding operations in 1969 and 1970 took place in South Vietnam.

Much of the basic research was provided by Navy scientists, and the seeding operations were flown by the Air Weather Service of the Air Force.

By 1967, or possibly earlier, the Air Force flights were originating from a special operations group at Udorn air base in Thailand. No more than four C–130's, and usually only two, were assigned in the highly restricted section of the base. Each plane was capable of carrying out more than one mission on one flight.

One former high-ranking official said in an interview that by the end of 1971 the program, which had been given at least three different code names since the middle nineteen-sixties, was under the direct control of the White House.

Interviews determined that many usually well-informed members of the Nixon Administration had been kept in the dark.

In the last year, there have been repeated inquiries and publicly posed questions by members of Congress about the weather modification programs in Southeast

Asia, but no accurate information has been provided to them by the Department of Defense.

"This kind of thing was a bomb, and Henry restricted information about it to those who had to know," said one well-placed Government official, referring to Henry A. Kissinger, the President's adviser on national security.

Nonetheless the official said, "I understood it to be a spoiling action—that this was descriptive of what was going on north of the DMZ with the roads and the SAM sites."

Another source said that most of the weather modification activities eventually were conducted with the aid and support of the South Vietnamese. "I think we were trying to teach the South Vietnamese how to fly the cloud-seeding missions," the source said.

It was impossible to learn where the staffing and research for the secret weather operation were carried out. Sources at the Air Force Cambridge Research Laboratories at Hanscomb Field in Bedford, Mass., and at the Air Weather Service headquarters, while acknowledging that they had heard of the secret operation, said they had no information about its research center.

One Government source did say that a group was "now evaluating the program to see how much additional rain was caused." He would not elaborate.

[From the New York Times, July 9, 1972]

PENTAGON: WEATHER AS A WEAPON OF WAR

WASHINGTON.—Dr. Gordon J. F. MacDonald, a prominent geophysicist who had just completed a tour as vice president of the Defense Department's Institute of Defense Analysis, published in 1968 a little-noted but chilling study on the military potential of meteorological warfare. He listed a number of options available to those who would choose to tamper with nature. Among them:

Altering the world's temperature by rocketing materials into the earth's upper atmosphere to either absorb light (thereby cooling the surface below) or absorb outgoing heat (thereby heating the surface below). This technique could be targeted at a specific area.

Triggering tidal waves by setting off a series of underground explosions along the edge of the Continental Shelf, or by producing a natural earthquake. A guided tidal wave could be achieved by correctly shaping the energy-release sources.

Changing the physical makeup of the atmosphere by creating, with a rocket or similar weapon, a "hole" in the important ozone layer between 10 and 30 miles up that is responsible for absorbing much of the ultra-violet light cast from the sun. Without the protective layer of ozone, a molecular form of oxygen, the radiation would be fatal to all human, plant and animal life that could not take shelter in the affected area below.

Dr. MacDonald (who is now a member of the White House Council on Environmental Quality) made it clear that his essay was based only on speculation. Last week, however, it became known that at least part of his macabre weather arsenal had been secretly in use by the United States since the 1960's.

Air Force planes, supported by the Central Intelligence Agency, have been waging a systematic war of rain on the infiltration trails of Laos, Cambodia, North Vietnam and South Vietnam. The intent: suppress enemy antimissile fire, provide cover for South Vietnamese commando teams penetrating the North and hinder the movement of men and materiel from North Vietnam into the South.

The first experimental rain-making mission was flown by the C.I.A. in South Vietnam in 1963, but it was not until 1965 that a group of Air Force scientists officially was ordered to start thinking of ways to turn nature into a military tool.

"We all sat down in a big brain-storming session," said one of the scientists who participated at the Air Force Cambridge Research Laboratories at Hanscomb Field near Bedford, Mass. "The idea was to increase the rain and reduce the trafficability in all of Southeast Asia."

Within a year, the Air Force and C.I.A. began a highly secret rain-making project over the Ho Chi Minh Trail in Laos, known as "Operation Pop-Eye." There were heated protests from the State Department, and eventually a directive from the Secretary of Defense Robert S. McNamara ordering a halt to the project. Instead, well qualified sources said last week, "it went underground—into the dark."

From 1969 through at least early this year, weather warfare was a covert operation being directed by the Joint Chiefs of Staff with White House acquiescence.

The fact that the program existed at all came to light only last week in The New York Times. But, despite an extensive investigation, if could not be learned how successful the program had been, how many missions were conducted or whether it was still being used in connection with the heavy bombing of North Vietnam that followed the enemy offensive last April.

Making rain has long been technically feasible. Scientists have learned that rain fall can be increased by as much as 40 per cent after seeding clouds by aircraft with silver-iodide particles. Other chemicals, including dry ice, also have been used with success, both in the United States and in Southeast Asia.

Military and Government specialists acknowledge that there is little precise scientific knowledge of the short-range impact of cloud seeding and practically none of the long-range ecological effect of changing the amount of natural rainfall. Some scientists have published data suggesting that weather modification, in combination with other ecological stresses such as air pollution and pesticides, may have a synergistic effect—that is, result in collective changes far greater than either abuse would have caused by itself.

In Indochina, where heavy bombing already has robbed much of the landscape of its natural water-holding capability by destroying foliage and trees, artificially induced rains may result in far greater flooding than expected, along with heavier soil erosion.

Technically, there are no international agreements outlawing such warfare. But Government officials made clear last week that the weather-making activity of the Air Force was shielded from public view because of White House sensitivity to what could be regarded as the impropriety of the action. The issue, one well-informed official said, was one in which Henry A. Kissinger, the President's national-security adviser, took a personal hand. "This kind of thing was a bomb," the official said, "and Henry restricted information about it to those who had to know."

Senator PELL. I hope that these hearings, today and tomorrow, will generate the action necessary to further this objective. We are pleased, therefore, to have before us this morning Mr. Herman Pollack who will present the Department of State's position.

I welcome Herman Pollack as an old friend and colleague in the days when I used to be in the Department, but I would also express a certain disappointment that the Secretary or the Under Secretary did not see fit to come and discuss the subject themselves. This is no personal reflection on Mr. Pollack, but I think it might have been more helpful to the committee if a witness of Mr. Alexis Johnson's level of responsibility had come forward.

I welcome Mr. Pollack as an old friend. I am glad he is here.

Would you like to proceed, Mr. Pollack?

STATEMENT OF HERMAN POLLACK, DIRECTOR, BUREAU OF INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL AFFAIRS, DEPARTMENT OF STATE; ACCOMPANIED BY CARL F. SALANS, DEPUTY LEGAL ADVISER

Mr. POLLACK. Thank you, Mr. Chairman.

My presentation this morning will first recount the interest and actions of the Department of State in recent years regarding policy on weather modification, a topic central to the resolution which is the subject of this hearing. Against that background I will then comment on the broader scope of the resolution.

STATE DEPARTMENT APPROACH TO NEW TECHNOLOGIES

The State Department follows closely the development of all new technologies which appear to have the potential of impacting on the international affairs of the United States.

Quite frequently, when a new branch of technology is in its early developmental phase, it is not possible to define with any precision its future impact, much less to be sure whether its impact will be primarily beneficial or primarily harmful. At early stages of development, the facts necessary to make such a judgment are simply not at hand. Under the circumstances, the formulation of general policy is premature and we establish a "watching brief." When the development of the technology reaches an appropriate stage, the Secretary's attention is drawn to it and the analysis and formulation of policy gets seriously underway.

The State Department approach to weather modification has followed essentially that pattern. Parenthetically, I might say that the art—if I may call it that—of climate, earthquake or ocean modification is not yet at a point where even a "watching brief," as we use the term, is in order. These are areas of great paucity of scientific data and understanding.

DEVELOPMENTS CAUSING ESTABLISHMENT OF WATCHING BRIEF

Returning now to weather modification, as you know experiments on the modification of clouds through seeding with various agents started shortly after the end of the Second World War and by the early 1960's it seemed likely that this technology, when further developed and when more answers were known, might some day produce vast benefits through enhancing rainfall and might also pose new tasks in international relations. At about the same time, the first efforts to moderate the intensity of hurricanes through seeding were initiated. It was these developments, nearly 10 years ago, that caused the State Department to establish its watching brief on weather modification; and responsibility for maintaining this brief was assigned to the Bureau which I head.

DEVELOPMENTS IN 1968 TO 1970 PERIOD

In the period 1968 to 1970 several developments occurred which made it clear that weather modification was progressing beyond the early experimental phase and was approaching the stage where at least a few types of human intervention in weather processes might well be approaching operational status. Among these developments I will mention three in particular:

The studies of the Department of Interior showed that proper seeding of winter clouds might enhance the snow-pack in the Colorado River Valley by perhaps 20 or 30 percent. Such an achievement would enhance the fresh water available in the whole river valley during the spring and summer months.

The experiments of Dr. Joanne Simpson and her associates at the NOAA (National Oceanic and Atmospheric Administration) laboratory in Miami produced manifold increases in the rainfall from isolated tropical cumulus clouds.

The experiments known as "Project Stormfury" aimed at moderation of violent hurricanes appear to have produced their first substantially positive results in a series of experiments on Hurricane Debbie of 1969.

REPLACEMENT OF WATCHING BRIEF BY MORE ACTIVE STUDY

This combination of events provided us with some of the information needed for the development of policy to control or facilitate the impact of this new technology. I have at hand the memorandum which I sent to Secretary Rogers on November 16, 1970, informing him that the time had come for the watching brief on weather modification to be replaced by a more active study of the implications for our foreign policy. It reported that:

> . . . U.S. scientists who have heretofore been very cautious and guarded in their assessment of progress in this field are now showing visible signs of excitement at recent events. This is especially so with regard to the highly successful seeding of cumulus clouds in tropical areas for the purpose of increasing rainfall. Equally a source of excitement is the mounting evidence that the force of hurricanes and typhoons can be lessened by seeding techniques.
>
> Clouds and storms are unconscious of sovereignty. International law on weather modification is practically nonexistent. The problems that operational weather modification technology will pose to this Department and the foreign offices of the world are therefore self-evident.
>
> Steps are underway to set up intra-Department and interagency committees to develop plans and policies for the international reception of this new technology.

Shortly thereafter, in a statement to the House Committee on Science and Astronautics, Secretary Rogers made particular mention of weather modification as a potential boon in assisting the economic problems of the developing nations. He also pointed to the need to consider international arrangements to deal with the applications of this new phenomenon. I was pleased to note, Mr. Chairman, that you quoted this section of Secretary Rogers' statement in your speech on the Senate floor last March 17.

CONCLUSIONS OF INTERAGENCY STUDY

The interagency study to which I referred in my memorandum to the Secretary got underway in the spring of 1971. The study which was completed earlier this year came to certain conclusions regarding civilian aspects of weather modification.

The objective of our programs is to advance civilian weather modification research and development efforts and to apply this technology for human benefit. To this end, we will further international cooperation and understanding in this rapidly developing field and conduct our programs with maximum openness and within the framework of clear safeguards designed to protect the interests of the United States and of other countries. With regard to assisting other countries, we will consider each request on the basis of its own merits. We will not, in any case, encourage activities involving a high risk of damage or where the effects cannot be foreseen with reasonable assurance.

Although the science of weather modification is still experimental and at an early stage in its development, the U.S. Government will maintain continuing review of the international aspects of weather modification generally.

The Department of State, with appropriate interagency support, is instituting and overseeing implementation of appropriate guidelines for U.S. activities, will review any requests from other countries for assistance in weather modification activity, and will report on policy issues as the need develops.

As was indicated in Mr. Abshire's letter of May 15, 1972, to Senator Fulbright, the study came to no conclusions with respect to international agreements on military aspects of weather modification.

CLIMATE MODIFICATION

With respect to climate modification, we shall continue research in this area in the hope that there may be a potential for human benefit. However, no climate modification experiment will be conducted until we can predict its total impact with great assurance and, of course, no such activity would be conducted without thorough consultations among interested agencies and approval at the highest levels of Government. I might observe that it goes without saying that the administration would not use techniques for climate modification for hostile purposes even should they come to be developed.

NOT ADOPTING SENATE RESOLUTION 281 RECOMMENDED

In summary, with respect to Senate Resolution 281 and simply stated, we believe that there is at present too much uncertainty about essential facts and that the factual basis itself is insufficient to make possible any fundamental decisions on whether a treaty dealing with military aspects is feasible and desirable. For example, how could we verify suspected violations or monitor compliance by other signatories of an international agreement prohibiting the use of weather modification, much less climate, earthquake, or ocean modification about which we know next to nothing? Furthermore, how could we distinguish between weather modification research and development which is directed toward military application and that which is to be used for purely civilian purposes, since the techniques involved may be the same?

Relevant questions such as these will have to be answered, through further study and research, before it is possible to formulate a solid basis for decisions on issues such as are raised by Senate Resolution 281.

It is therefore our conclusion that actions such as those recommended in Senate Resolution 281 are premature. Accordingly, the Department of State recommends that this resolution not be adopted.

Mr. Chairman, that concludes my statement. I will be pleased to respond to questions.

I am accompanied by Mr. Salans, of the Office of Legal Adviser.

Senator PELL. Thank you very much for a very clear statement of unclear intentions.

I appreciate the position in which you are. In going through your statement, I made a couple of notes as we were moving along.

REASON FOR NOT MENTIONING U.S. OPERATIONS IN SOUTHEAST ASIA

You said:

> In the period 1968 to 1970 several developments occurred which made it clear that weather modification was proceeding beyond the early experimental phase and was approaching the stage where at least a few types of human intervention in weather processes might well be approaching operational status.

I believe at that time the Department of Defense was conducting weather modification activities in Southeast Asia.

Are you free to say why these operations were not mentioned in your statement?

Mr. POLLACK. Mr. Senator, in his letter to Senator Cranston and Congressman Gude of March 18, Secretary Laird indicated there were some aspects of the work of the Department of Defense which had a definite relationship to national security and possible uses of weather modification which were classified accordingly.

Therefore, I regret that I am unable to discuss the question which you have raised.

TERMS OF REFERENCE OF INTERAGENCY STUDY

Senator PELL. You mentioned an interagency study, which I believe you chaired. Could you give us the terms of reference of that study? Could you describe it to us?

Mr. POLLACK. I am afraid that the terms of reference of the study or its content would have to be considered as internal executive branch documents. I don't believe I can make those available.

Senator PELL. I realize that, but could you outline them to us for the committee? You are dealing with the subject of the broad range of weather modification. Without going into the question of executive privilege or classification, could you give us an idea of the broad outline of that study?

Mr. POLLACK. I think the nature of the conclusions that I describe beginning on page 5 do indicate the subject matter that was covered within the study.

Senator PELL. But you would not be free in an open session to give us any more of the actual terms of reference that were given to you for conducting that study?

Mr. POLLACK. I do not believe so.

POTENTIAL SERIOUSNESS OF PROBLEM

Senator PELL. In view of your capacity as chairman or as Director of the Bureau of International Scientific and Technological Affairs of the Department, do you believe that this type of warfare is a potentially serious problem?

Mr. POLLACK. I believe that the statement that I read with respect to weather modification would clearly indicate that my answer is in the affirmative.

DIFFERENCE BETWEEN CLIMATE AND WEATHER MODIFICATION

Senator PELL. Incidentally, in connection with that statement, I was most struck by your phrase:

> I might observe that it goes without saying that the administration would not use techniques for climate modification for hostile purposes even if they should come to be developed.

What, in your view, is the difference between climate modification and weather modification?

Mr. POLLACK. I think the basic distinction that I would make and that most others make is that climate modification is generally thought of as long-term, not in terms of years or decades but possibly centuries.

The extent of climate modification is generally conceived of to be widespread, not involving a limited area but areas occupied by one, two, three, or numerous nations.

Weather modification is transitory, temporary, and limited in its geographic impact.

WOULD ADMINISTRATION ESCHEW WEATHER MODIFICATION TECHNIQUES?

Senator PELL. In other words, the phrase you are using here is carefully chosen. It would not apply to weather modification. You are saying specifically climate modification?

Mr. POLLACK. This phrase relates to climate modification as I have described it; yes.

Senator PELL. You would not be willing to make the statement that the administration would eschew techniques for weather modification for hostile purposes?

Mr. POLLACK. No; this statement, sir, is directed toward climate modification.

(Committee staff note: An excerpt from the testimony of Dr. Pierre St. Amand during hearings entitled, Weather Modification, Hearings before the Committee on Commerce, United States Senate, 89th Congress, 1st and 2nd Sessions on S. 23 and S. 2916, bills relating to weather modification, Part 1, " follows:)

STATEMENTS OF COMDR. PAUL T. JORGENSON AND DR. PIERRE ST. AMAND, GEOPHYSICS GROUP, NAVAL ORDNANCE TEST STATION, CHINA LAKE, CALIF.

Dr. ST. AMAND. The Naval Ordnance Test Station began work in weather modification in 1961 taking advantage of the fact that we have an almost unique position in the country to do development work in the production of nuclei for cloud seeding. The original work depended on an invention by a pair of chemists who worked there—a Dr. Burkhart and Dr. Finnegan—in which they developed a method for producing a reaction from silver iodide or lead iodide smoke. As time has gone by the program has expanded. The number of things we now produce for weather modification has greatly increased and the scope of our interest has increased.

Primarily the work is aimed at giving the U.S. Navy and the other armed forces, if they should care to use it, the capability of modifying the environment, to their own advantage, or to the disadvantage of an enemy. We regard the weather as a weapon. Anything one can use to get his way is a weapon and the weather is as good a one as any.

COMPOSITION OF INTERAGENCY COMMITTEE

Senator PELL. Going back to the interagency committee which you chair, would you be free to discuss the composition of the committee, the membership of it?

Mr. POLLACK. To the best of my recollection, the membership consists of those agencies who are, of course, members of the National Security Council. I would have to check back. I am sure the Department of Commerce was represented, which is not ordinarily a member of the National Security Council. I would have to check whether there were any other agencies. This would mean State, Defense, and all the other agencies that are members of the NSC ordinarily, plus the Department of Commerce.

REPORT PRODUCED BY WITNESS'S COMMITTEE

Senator PELL. You say your committee did produce a final report?
Mr. POLLACK. I beg your pardon?
Senator PELL. Did your committee produce a final report?
Mr. POLLACK. We produced a report. I am hesitating on the use of the term "final," because the subject is under continuing review.
Senator PELL. The date was May 1972?
Mr. POLLACK. That may be right. It was completed earlier this year.
Senator PELL. Would you be free to tell us the classification of that report?
Mr. POLLACK. I frankly don't recall.
Senator PELL. But it is classified? You are sure of that?
Mr. POLLACK. I assume it was, sir.
Senator PELL. If it was not classified, could we have it included in the record?
Mr. POLLACK. It was classified.
Senator PELL. Maybe the attorney could recall if it was top secret.
Mr. POLLACK. I simply don't recall the classification.
Senator PELL. I wonder if you can submit the classification for the record.
Mr. POLLACK. I should think so.
Senator PELL. Would that be proper?
Mr. POLLACK. We will examine whether we can.
Senator PELL. You can't make a commitment that you will let us know the classification of the report?
Mr. POLLACK. I think we can.
(The information referred to follows:)

CLASSIFICATION OF INTERAGENCY STUDY REPORT

(Supplied by Department of State)

The classification of the report was confidential.

Senator PELL. I thank you very much.
Did your report take into account the current belief that the United States is engaging or has engaged in weather modification in Southeast Asia?
Mr. POLLACK. Senator Pell, I regret I will have to return to the earlier statement, that this was an internal executive branch document, and I am not at liberty to reveal its contents.

STUDY'S CONSIDERATION OF MILITARY USES OF WEATHER MODIFICATION DOUBTED

Senator PELL. Not having had, as you know, a briefing on this subject, though I believe this information should be in the public domain, I consider myself a little freer in that regard. I have reason to believe that you did not consider the military uses of weather modification as reported.
I guess I am getting into very complicated points here, but bear with me for a moment. Presuming I am correct and you did not have access to its current military uses, would you be able to give me any reasons as to why you think you were not given access to its military uses?

Mr. POLLACK. Senator, I am afraid I didn't follow that.

Senator PELL. It is very complicated. I have reason to believe that your study did not get into the military uses of weather modification, that you were not given access to it. Would you be able to confirm that statement in any way?

Mr. POLLACK. Senator, the study did get into military uses.

Senator PELL. It did?

Mr. POLLACK. Yes.

Senator PELL. I am not only delighted, but interested.

Mr. POLLACK. I should really say military aspects rather than military uses. We did cover the military as well as the civilian.

Senator PELL. The military and civilian aspects?

Mr. POLLACK. The study came to no conclusions, as I stated earlier, with respect to international agreements on military aspects.

SAFEGUARDS RELATING TO U.S. INTERESTS

Senator PELL. In your statement, you say, "To this end we will further international cooperation and understanding in this rapidly developing field and conduct our programs with maximum openness and within the framework of clear safeguards designed to protect the interests of the United States and of other countries." What do you mean by the phrase, "within the framework of clear safeguards designed to protect the interests of the United States"?

Mr. POLLACK. Among the safeguards that would relate to the interests of the United States would be the liability provisions.

Senator PELL. The what?

Mr. POLLACK. The liability, safety from liability claims. We are here discussing conducting a program internationally. We have received a request from the Azores, just 10 days ago, and a program is currently underway at the request of the Portuguese Government to try to augment the rain in a drought-ridden area of the Azores.

Protecting the interests of the United States in that case would be, No. 1, to make sure that we are satisfied that there would be no risk to the environment or ecology of the area or to third parties; second, to be fairly confident that we knew what the consequences of our seeding would be and that we were not engaging in a completely speculative activity.

The third factor, and there may be others, would have been the one I mentioned earlier of protecting ourselves from any liability, requesting the Portuguese Government to take on that responsibility if they wished this service.

OVERSEEING IMPLEMENTATION OF APPROPRIATE GUIDELINES

Senator PELL. Then you say that the Department of State, with appropriate interagency support, is instituting and overseeing implementation of appropriate guidelines for U.S. activities, to review any requests.

Does this mean overseeing implementation of appropriate guidelines for U.S. activities both of a civilian and military nature or only of a civilian nature?

Mr. POLLACK. The paragraph you read is a further discussion of the civilian aspects of weather modification.

Senator PELL. You would not be instituting or overseeing implementation of appropriate guidelines of all activities?

Mr. POLLACK. I think the question of whether that would go beyond civilian returns to the earlier position I took with respect to the national security aspects of military activities, and I simply cannot go into that.

Senator PELL. I realize we are dancing around on the head of a pin, but we have all this secondary evidence or information that leads one to believe military activities are being engaged in. I don't think there is a person in this room who doesn't.

I would hope eventually that this fact could be brought into the open, but this is a decision of the executive branch.

PARALLEL OF DRAFT SEABEDS TREATY

Returning to more general questions in connection with my proposed treaty, I would draw a parallel between it and a draft treaty in the form of a resolution introduced some years ago that would have prohibited nuclear and other weapons of mass destruction on the seabed and ocean floor, 70 percent of the earth's surface.

I can remember the immediate response of the executive branch, then under President Johnson's guidance, was very much the same as now, rather unenthusiastic or nonresponsive with regard to these possible weapons systems.

At that point, these weapons systems were only on the drawing boards, the ABM's for the mid-Atlantic seabed floor, and were not in use in any way.

But the men in the Pentagon, and presumably in the Kremlin, wanted to have their options kept open and wanted no part of an agreement which would eschew the use of these weapons. After 5 years, I had the satisfaction of seeing an agreement concluded prohibiting such weapons on the seabed floor.

Fortunately, these drawings have remained drawings. The problem now is that we are talking about weapons systems that are, in my view, in being, not just on the drawing boards. That is why I hope that the 5-year lag it took to bring forth an agreement with regard to weapons on the seabed floor would be shorter in this case.

STATE DEPARTMENT POSITION ON AGREEMENT PROHIBITING ENVIRONMENTAL WARFARE

In connection with that, what are the considerations in favor of an international agreement prohibiting the use of environmental warfare? Do you have a general view in the Department with regard to a general prohibition on using environmental warfare as a means of warfare?

Mr. POLLACK. Could you be a little clearer as to what you mean by environmental warfare?

Senator PELL. What are the considerations in favor of an international agreement prohibiting the use of environmental warfare?

I am not saying you approve of it, but what is your own position as director of the scientific branch? What are the elements in favor of such an agreement along the lines that we Senators have proposed?

Mr. POLLACK. Sir, if you are talking about environmental warfare, I fear I need to know more precisely what we are talking about.

Senator PELL. We are talking about weather modification, geophysical modification. I am talking about these uses of weather modification techniques.

Mr. POLLACK. The general position that we have tried to reflect in this statement is that we simply at this point do not have enough data on hand to know what a prudent posture for the United States to take would be with respect to international arrangements, be they treaty or others, with respect to the subject of your resolution.

CONSULTATION UNDER STOCKHOLM CONFERENCE RECOMMENDATION 218

Senator PELL. Some of us were at the Stockholm Conference on International Environment. I think it was one of the most significant conferences in which this Nation has engaged for a long time.

At that conference there was a recommendation, No. 218, which had to do with whether the eschewing of weather modifications should exist. It was pretty well gutted by the United States inserting the phrase that we would only consult with other nations when we engaged in weather modification techniques "to the maximum extent feasible."

I was wondering if you would let us know under what circumstances would it not be feasible for the U.S. Government to report its weather modification activities. I add that the phrase "to the maximum extent feasible" was inserted at the request of the executive branch at that conference.

Mr. POLLACK. May I say a word or two about that?

Senator PELL. Certainly.

Mr. POLLACK. There were two clauses in the proposed recommendation. The recommendation was No. 218. The first clause recommended that governments "carefully evaluate the likelihood and magnitude of climatic effects and determine their findings before embarking on such activities." The phrase, "to the maximum extent feasible" relates to that clause.

The second clause recommended that governments "consult fully other interested states when activities carrying a risk of such effects are being contemplated or implemented." The phrase "wherever practicable" related to the second clause.

Senator PELL. In other words, the "feasible" relates only to the first clause—to carefully evaluate the likelihood and magnitude—but not to the second one—to consult fully?

Mr. POLLACK. Yes; "to the maximum extent feasible was inserted" at the recommendation of the United States. It was made in advance of the conference. It was to amend the verb "disseminate."

This is a rather common problem with respect to the obligation as to how far you have to go in making documents and data available to how many different nations, and so forth. I don't know what the legal term would be, but in my judgment it would be a clause of reason.

Senator PELL. Am I correct in saying that the second phrase, "consult fully other interested states when activities carrying a risk of such effects are being contemplated or implemented" remains unqualified?

Mr. POLLACK. That remained unqualified.

Senator PELL. Pressing the subject for a moment, if I may, if for the sake of argument one was engaged in weather modification activities in any part of the globe, would that mean then that we have an obligation to "consult fully other interested states when activities carrying risks of such effects are being contemplated or implemented"?

Mr. POLLACK. This recommendation was adopted by the conference in Stockholm. The subject will come up before the General Assembly this fall. The legislative history that will accompany this has not yet been established. But at the moment this is a recommendation to the governments. This is not an obligation upon the governments.

Senator PELL. In other words, if this recommendation is implemented, it would then mean that if we were engaged in weather modification in any part of the world, we would then, if we accepted the recommended obligation, be obligated to consult fully other interested states?

Mr. POLLACK. I assume if it were an obligation and we accepted the obligation, your statement would be correct.

QUESTION OF CONSULTATION UNDER RECOMMENDATION 218

Senator CASE. You have made a very good explanation of this. But why don't you come clean and say, "Sure, we will consult, and this is a universal obligation"?

You have made it clear that to the extent feasible applies only to the dissemination part. Why don't you give the appearance as well as have the substance of frankness with us? Have you any reason not to?

Mr. POLLACK. It is simply, sir, that the meaning of this clause has not yet been established. It has not yet been acted on by the General Assembly.

Senator CASE. What effect did we mean it to have?

Mr. POLLACK. It might be helpful if I were to read the position that the United States carried into the Stockholm Conference with respect to that.

Senator CASE. The point is that Mr. Pell is a Democrat. He is interested in making his own case. I am a Republican and I am interested in having you make the best case for the administration. Will you come clean with it?

Mr. POLLACK. Yes, I will. I have been trying to do that this morning.

Senator PELL. I will add that we are both Americans.

Senator CASE. Of course we are, but you know what we are doing.

Senator PELL. We want to see a treaty like this passed. When we had a Democratic administration, with all due respect to my Republican colleague, I went after the administration just as hard.

Mr. POLLACK. The last time this question was examined was in connection with the preparation for the Stockholm Conference. I am reading now from the position paper dated May 15, that was prepared for the instruction of our delegation. It said with respect to the amendments, that is both of the amendments, that if they fail, the delegates should not support the recommendation unless he makes a statement to the effect that "the recommendation is unrealistic because it fails to take into account the imperfect state of our knowledge as to the mechanism by which man's activity might

affect climate and thus in turn affect the ability of the government to do more than what is feasible and practical in meeting all of the terms of the recommendation."

I do not believe that the U.S. Government has since reconsidered this question. Of course, it will have to do so as it prepares for the discussion of this item at the General Assembly meeting.

But this represents the last authoritative position of the executive branch with respect to those two recommendations.

Senator PELL. At Stockholm, and Senator Case was there, too, I took exception to the insertion of this phrase because I thought it basically gutted the recommendation. I didn't realize you were only talking about paragraph A. I thought you were talking about B.

But I believe this gutted that phrase. I was very much in a minority. I believe very strongly that when you go outside the United States your delegation has to speak with one mouth. You can't speak with different mouths. I kept my mouth shut publicly. But in the delegation meeting I protested privately. Within the delegation I was concerned about the use of this phrase.

I wonder in this regard why the administration or the delegation proposed the second phrase, "consult fully other interested States whenever practicable." That was defeated, as you know.

Mr. POLLACK. I think, sir, the reason that was incorporated in the position paper before the delegation is responsive to that.

Had I been commenting on this personally, I would have found it very difficult to know at what point contemplation begins, for example. The terminology leaves something to be desired. When I agree to consult about what I begin to contemplate, I need to understand a little bit more about what the process of contemplation is.

If I am going to take an absolute obligation to consult, that is.

WEAKENING OF U.S. POSITION AT STOCKHOLM SUGGESTED

Senator PELL. I think these little amendments that were put in, some of which were accepted and some of which were not, combined with the concern about herbicides in the back of most people's minds there, helped give our position at Stockholm a certain weakness. It did not give us the strongest position we really should have had because we played such a huge role in trying to move ahead into the Stockholm Conference.

VALIDITY OF PRESS ARTICLES

You have probably read the articles in the press by Mr. De Silva of the Providence Journal, Seymor Hersh, New York Times, Mr. Wilford of the New York Times, and also in the Washington Post.

Have you any comment on the validity of these articles?

Mr. POLLACK. No, sir.

Senator PELL. You are not in a position to comment?

Mr. POLLACK. I have no comment on them.

IMPORTANCE OF TREATY

Senator PELL. I thank you very much for coming forward. I would hope as the months and years go by we really could move ahead

and get a treaty of this sort. As I said earlier, it is much more important than the treaty with regard to the seabed and ocean floor because the evidence would point to the fact we are talking about weapons systems in being and not on the drawing board.

I thank you very much.

Senator Case?

QUESTIONS FOR THE RECORD

Senator CASE. Mr. Chairman, I would like to ask Dr. Pollack to take some questions, which I will not ask now, and answer them for the record.

Mr. POLLACK. I will be pleased to do that, sir.

Senator PELL. I would hope in unclassified form.

Mr. POLLACK. Yes, sir.

Senator CASE. Yes.

Senator PELL. I thank both of you for coming today.

Our next witness is Mr. Philip J. Farley, Deputy Director of the U.S. Arms Control and Disarmament Agency.

STATEMENT OF PHILIP J. FARLEY, DEPUTY DIRECTOR, U.S. ARMS CONTROL AND DISARMAMENT AGENCY

Mr. FARLEY. Thank you, Senator Pell.

Mr. Pollack has described for you our policy on certain international aspects of weather modification, and identified other areas where study is still required. In support of his statement, I will address briefly the area of arms control.

In holding these hearings on Senate Resolution 281, you are seeking to focus attention on a potential preventive arms control measure. My agency is of course mindful, Mr. Chairman, of the similar role you played in connection with another arms control measure—the Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and on the Subsoil Thereof. We agree that the possibilities of arms control in this new field deserve the most careful study and consideration, along with other international aspects of civilian environmental modification activities.

As Mr. Pollack has indicated, this administration has already begun this process. My agency participated in the preliminary study of the international aspects of weather modification activities, done by the NSC Under Secretary's Group, and will participate in the continuing review. I want to assure this committee that, while this is a relatively new subject, we in ACDA are very conscious of our responsibility to see that in this process relevant arms control aspects are fully considered.

However, given the need for further understanding of these subjects, we are not prepared to endorse a resolution to the effect that we should seek the agreement of other governments to a specific treaty, or to take positions on the substance of the matter.

I noted, in the speech with which you introduced the resolution to the Senate, that one of your objectives was to generate discussion of the subject. In this spirit, I want to make one general observation.

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Your draft treaty applies not only to experimentation or use of any environmental or geophysical modification activity "as a weapon of war," but also to research. Does this take sufficient account of the nearly identical nature of the techniques involved in civilian and military applications of these activities? It may be impossible to distinguish between research and perhaps testing on such applications as cloud seeding, for military or civilian purposes. How would it be possible to avoid the consequences of hampering research on what might be highly desirable civilian applications? If these problems were avoided by restricting your proposal to a limitation on the use of such activities, this would leave the question, referred to by Mr. Pollack, of whether and how we could satisfy ourselves as to compliance with any such agreement.

Let me conclude, Mr. Chairman, by thanking you for bringing your proposal to public attention. We will examine carefully the testimony and discussion during these hearings to be sure we are taking into account all relevant information and points of view.

This concludes my brief statement, Mr. Chairman.

RESEARCH RELATED TO CIVILIAN USES

Senator PELL. I thank you for your statement. I think your point about research, and not prohibiting its use because of its relationship to civilian uses, is a pretty valid one. I think in the public domain it would pretty well take care of itself.

EFFORT IS TO REMOVE SECRECY

What I am trying to do, and many of us in the Congress are trying to do, is to try to get the secrecy removed from this area. If we can remove the secret nature of these activities, I think many of the pieces will then fall in place.

But it is the very secrecy of the operation that adds, I think, to its danger for the future.

An excellent series of examples was given by Gordon McDonald in his book about 5 years ago. He mentioned the point that it is the secrecy of these activities that perhaps enhance the military use. A nation might not even be aware of the fact that these various activities were being engaged in as they suffered from the results.

POSSIBLE PREFERABILITY OF TERM "ESCHEW"

I think your suggestion with regard to research is a good one. Another change that I intend to make in the second draft of this treaty, because the draft in Senate Resolution 281 is merely the first of half a dozen drafts of the final agreement that I hope will finally be signed and come into effect, is to use the word "eschew" rather than "prohibit" or "prevent."

I understand that has a better legal sense. Would you comment in that specific regard, from the viewpoint of the ACDA, why it is that the word "eschew" is more preferable to "prohibit" or "prevent?"

Mr. FARLEY. Mr Chairman, this is a new idea to me. If you wish, I would be glad to have some thought given to this and give you an answer, but I have not considered this question of the possible preferability of the term "eschew."

Senator PELL. I would be grateful and I would hope also it would be in an unclassified form.

(The information referred to follows:)

USE OF WORD "ESCHEW" IN LIEU OF "PROHIBIT AND PREVENT"

(Supplied by ACDA)

Without having had the benefit of hearing the arguments of those who have suggested the use of the word "eschew" in lieu of "prohibit and prevent," I can offer only the following initial reactions:

1. The word "eschew" suggests to me avoidance, and thus might not amount to an unqualified undertaking. On the other hand, if the use of that word is intended to allow activities such as rescue of downed airmen or fog dispersal at airports, it would seem to me to be an unreliable way of achieving this objective.

2. The words "prohibit and prevent" appear to be derived from the undertaking in Article I of the Limited Test Ban Treaty, in which the parties undertake "to prohibit, to prevent, and not to carry out" nuclear explosions of specified types. There the words "prohibit and prevent" appear to me to add to the undertaking of the state not to carry out the proscribed activities a responsibility to take appropriate action to ensure that its employees, agents, or others under its jurisdiction or control do not carry out such activities.

OPENNESS OF RESEARCH

Mr. FARLEY. Could I just say, because my silence might be misinterpreted, that in your previous remarks when you spoke of the importance of avoidance of secrecy, I was not clear whether you intended those to apply to research, which was what the discussion began with.

It is my understanding that the research in this field is open. I would not want the contrary impression appear to be one that I agreed with.

Senator PELL. I understand there is classified research in this field being conducted under the Defense Department. The next witness will be able to shed light on that. I would be delighted if he indicated that this research was not classified.

OTHER NATIONS' INTEREST IN SUBJECT OF TREATY

In connection with the general background, are you familiar with any other interest in or discussion of the subject of this treaty from other nations.

Mr. FARLEY. I am not aware of any of a governmental nature. There have been some suggestions from nongovernmental bodies, but there has not been active discussion, to my knowledge, of this matter, for example, in the United Nations or in the Geneva Conference or the Committee on Disarmament. Again, if I am ignorant of anything, I will supplement that answer.

OTHER PROPOSALS ON SUBJECT

Senator PELL. Also, what proposals on this subject have been made by other nations or international groups or within our own Government? Maybe you could submit this for the record at a later date, if there are any other proposals.

I am trying to get together in this hearing all of the information obtainable.

Mr. FARLEY. The only one I am aware of is by the body known as World Peace Through Law Center. You may be acquainted with that.

OTHER NATIONS' POTENTIAL FOR WEATHER MODIFICATION ACTIVITIES

Senator PELL. Do you believe that other nations have the potential to engage in weather modification activities directed against our own Nation?

Mr. FARLEY. There are a number of other nations who are engaged in research on weather modification and who have a general technical capability in this field. Indeed, I believe one of your subsequent witnesses, perhaps not today, will say something about what is being done in this general field by other countries.

That suggests, therefore, that one of the questions which we have to look at in considering the merits of an arms control approach is the possibility that we may have more to gain by a general agreement which removes the threat to us than we have to gain from uses of our own of these techniques for military purposes. That is one of the questions we have under examination.

PAST RECOMMENDATIONS TO LIMIT U.S. WEATHER MODIFICATION ACTIVITIES

Senator PELL. I think it was about 7 years ago, in 1965, a Special Commission on Weather Modification recommended to the National Science Foundation a Presidential statement of policy limiting American weather modification activities to peaceful purposes.

In 1966, a year later, a report entitled "Weather Modification and Control," prepared for the Commerce Committee, had the statement to the general effect that such an agreement should be signed or should be moved ahead.

What was the response of the ACDA to comments such as these when they were made 6 or 7 years ago?

Mr. FARLEY. I do not know of any response by ACDA at that time. My awareness of an ACDA interest in this subject dates essentially with the beginning of the interagency study which Mr. Pollack has made reference to in his statement and discussion with you.

Senator PELL. You were part of that interagency study?

Mr. FARLEY. Yes. I might add that that is one reason that I am here today in reply to your letter to Mr. Smith, since in his absence I represented ACDA.

INFORMING ACDA OF U.S. ARMED SERVICES WEATHER MODIFICATION ACTIVITIES

Senator PELL. Is your agency fully and currently informed regarding weather modification activities, no matter what kind, of the U.S. armed services?

Mr. FARLEY. It is always difficult to answer flatly whether one is fully informed.

Senator PELL. We weren't informed in the Foreign Relations Committee that we were conducting a war in Laos until it had been going on for almost 2 years.

Mr. FARLEY. I cannot say unequivocally that I am.

HAS ACDA OPPOSED WEATHER MODIFICATION ACTIVITIES IN INDOCHINA?

Senator PELL. I realize the restrictions under which you operate, but has the ACDA opposed weather modification activities by military and civilian agencies in Indochina?

Mr. FARLEY. We have not been involved in any discussion of this issue.

Senator PELL. You have not been involved in any discussion of it?

Mr. FARLEY. No.

Senator PELL. Senator Case?

Senator CASE. I think, Mr. Chairman, you have raised those questions that I would like to have Mr. Farley answer on the record. I have no questions. Thank you very much.

Senator PELL. Thank you very much, indeed, Mr. Farley.

Mr. FARLEY. Thank you.

Senator PELL. Our next witness is Benjamin Forman, Assistant General Counsel, International Affairs, Department of Defense.

STATEMENT OF BENJAMIN FORMAN, ASSISTANT GENERAL COUNSEL, INTERNATIONAL AFFAIRS, DEPARTMENT OF DEFENSE

Mr. FORMAN. Mr. Chairman, before presenting my prepared statement, I would like to acknowledge receipt of your letter to Secretary Laird, which we received on this past Monday, July 24, requesting that Dr. St. Amand accompany me as backup witness.

In checking to ascertain whether this request could be met, it was found that Dr. St. Amand was out of the country and could not return in time to be with me at this hearing.

Senator PELL. I regret that. Does that mean that the Department of Defense will be perfectly willing to have him come up as a witness at another time when he is in this country?

Mr. FORMAN. As a Department of Defense witness?

Senator PELL. Yes.

Mr. FORMAN. I don't know the answer to that. Offhand I don't see any objection.

Senator PELL. He is out of the country, not in Philadelphia?

Mr. FORMAN. No, he is out of the country. In fact, he is in the Azores at the moment engaged in the cloud seeding to which Mr. Pollack referred.

Senator PELL. Thank you very much.

Mr. FORMAN. Mr. Chairman, and members of the subcommittee: Along with such other Government agencies as the Department of Agriculture, Commerce, Interior, Housing and Urban Development, Transportation, the National Aeronautics and Space Administration, and the National Science Foundation, the Department of Defense conducts research and development programs pertaining to the general subject matter of this hearing under the aegis of the Interdepartmental Committee for Atmospheric Sciences (ICAS) of the Federal Council for Science and Technology.

In relative dollar terms, the research and development effort of the Department of Defense in this area is approximately .05 percent of the Department's total research and development budget. Comparing our relative level of effort in dollars with that of the other Government agencies involved, the Department of Defense ranks

fourth. The major portion of the national weather modification research and development programs is conducted by the Departments of Commerce and Interior, together with the National Science Foundation.

The Department of Defense has no unique weather modification techniques. Its research and development projects relating to environmental and geophysical modification activities are conducted on an unclassified basis. The results of the research and development are available to the public through the National Technical Information Service of the Department of Commerce.

MAJOR DEFENSE INTERESTS

Research by the Department of Defense in this area is conducted because of two major defense interests. The first of these is the protection of personnel and resources against weather hazards and thus the improvement of our operational capabilities. Research programs to meet this objective include investigations of techniques to dissipate warm fog and cold fog and the seeding of cumulus clouds to inhibit or enhance their growth. The President's budget for fiscal year 1973 proposes $1,429,000 for this area of research by DOD. The second major interest is guarding against technological surprise by increasing our understanding of the capabilities any potential enemy might possess in this area. To this end the President's budget for fiscal year 1973 proposes $3,090,000 for exploratory development by DOD, designed to develop a capability to predict climatic change due to natural phenomena or inadvertent or deliberate human actions. This research depends heavily on computer simulation; it is a threat exploration program to determine whether there is a threat, where it is, and of what it might consist.

CONDUCT OF DOD RESEARCH AND DEVELOPMENT

Department of Defense research and development is conducted both in the laboratory (DOD, academic, and industrial) and in the field. As indicated in the report of the Inter-departmental Committee for Atmospheric Sciences, the field efforts are usually joint efforts with other government agencies. One of the best known of these efforts has been the one conducted with the Department of Commerce (NOAA), known as Project Stormfury, which has investigated the possibilities of ameliorating the severity of damage caused by hurricanes and typhoons.

WEATHER MODIFICATION OPERATIONS

The Department of Defense also conducts some weather modification operations. We have not, as Secretary Laird has previously stated to the parent committee of this subcommittee, ever engaged in weather modification activities over North Vietnam. The Department of Defense has conducted cold fog modification at air bases in Alaska, the United States and Germany, where there is significant occurrence of the cold fog phenomena. It has participated in rain enhancement projects in Texas, India, the Philippines, and Okinawa. As announced to the press on July 21 by the Department of State, the

Department of Defense is currently undertaking a rain enhancement project in the Azores at the request of the Government of Portugal, which was made through diplomatic channels, in an effort to relieve severe drought conditions. Reports thus far received indicate favorable but not yet definitive results. As Mr. Pollack has indicated to the committee, all such requests for assistance are subject to thorough interdepartmental review in Washington. This review includes an evaluation of the probable effects.

INADEQUACY OF KNOWLEDGE CONCERNING ATMOSPHERIC SCIENCES

Notwithstanding the fact that studies in this area have been conducted now for some 25 years by the Federal, academic, and industrial communities, there remains a great deal that the Department of Defense does not know about the atmospheric sciences. As indicated in the June 1971 ICAS report on weather modification, there are a number of technical problems on which further research and development is required. According to Department of Defense researchers, our knowledge of other areas of environmental and geophysical modification is even more inadequate.

HOLDING ACTION ON S. RES. 281 IN ABEYANCE RECOMMENDED

In light of our present state of knowledge, the Department of Defense believes that it does not yet have sufficient knowledge to make an informed judgment as to whether a treaty along the lines of Senate Resolution 281 would be in the national interest. Similarly, this Department is not able intelligently to draft such a treaty if a treaty were, in fact, in the national interest. And, finally, the Department does not possess at this time the requisite scientific knowledge and techniques to be able to verify compliance with such a treaty.

In the circumstances, the Department of Defense is not in a position to comment on the substance of Senate Resolution 281. It accordingly recommends that committee action on the resolution at this time be held in abeyance.

Senator PELL. Thank you very much indeed.

BASIS OF DOD INTEREST IN WEATHER MODIFICATION

I have several questions that I would like to ask you. What is the reason for the Department of Defense's interest in weather modification, the basis for it?

Mr. FORMAN. As I indicated in my prepared statement, our basic reason in the field of weather modification is to protect our personnel and resources against weather hazards and thus improve our operational capabilities. I mentioned in this regard, for example, the problem of cold fog dissipation which has an obvious impact on the ability of our planes to take off and land from air fields where the cold fog phenomena exists. Similarly, of course, you have the problem of thunderstorms, hail, lightning, and how they might affect operations while you are flying.

Senator PELL. You say protection of personnel against weather hazards and improved operational capabilities are perhaps prime defense interests. Why would you want to seed cumulus clouds to enhance their growth? The two would go against each other.

Mr. FORMAN. I don't think they necessarily do. Let's take, for example, the question of the Azores. Why is the Department of Defense engaged in the operation in the Azores rather than the Department of Commerce, for example, which I suppose could equally do the job? We have, as I am fully aware this committee knows, bases in the Azores. We have personnel there and they are, of course, affected by the drought condition. It is, therefore, in our interest to be able to alleviate that condition, apart from the general interest in good relations with Portugal and the benefits to the people who live in the Azores.

(The following information was subsequently supplied:)

TECHNICAL CONSIDERATIONS WHICH LEAD DOD TO CONDUCT RESEARCH ON ENHANCING GROWTH OF CUMULUS CLOUDS

(Supplied By Department of Defense)

There are also several technical considerations which lead DOD to conduct research on enhancing the growth of cumulus clouds.

1. Knowledge of enhancement technology complements and furthers the attainment of inhibition technology.
2. Enhancement of cloud growth is a possible technique for hail and lightning suppression.
3. Causing rainfall in unpopulated areas some distance from our bases and installations may reduce the possibility of damaging storms afterwards in the vicinity of those facilities.
4. To build a technology base for the capability to verify the use of weather modification by an enemy.

BEGINNING OF DOD WEATHER MODIFICATION RESEARCH

Senator PELL. When did the Defense Department begin its research in the whole area of weather modification?

Mr. FORMAN. I don't know the exact date. Dr. Foster's letter to you earlier this year indicated it was some years ago.

PAST AND PRESENT DOD WEATHER MODIFICATION RESEARCH PROJECTS

Senator PELL. I wonder if you could describe now or submit for the record in an unclassified form a running statement of past and present DOD research projects related to weather modification.

Mr. FORMAN. Yes; I could submit for the record—for example, I happen to have brought with me a technical report, No. 244, of the Air Weather Service of the U.S. Air Force, which is their fourth annual survey report on the weather service modification program. It is a public document.

Senator PELL. We would like to have it in our files, if you could. Maybe you could give a compilation of the different programs.

Mr. FORMAN. This discusses a number of programs which were conducted during the fiscal year 1971. It is the most recent report to have been published. It was published in April of this year. Would you like earlier reports?

Senator PELL. I would like the dates and a sentence description of each program for the record. Could you submit that for the record?

Mr. FORMAN. Yes.

Senator PELL. Thank you very much.

(The information referred to follows:)

Department of Defense Research Projects Related to Weather Modification

(Supplied by Department of Defense)

PART I

Examples of Department of Defense R&D Projects in Weather Modification: FY 71, 72, & 73.

Fiscal year 1971

Army: Continued a basic review of materials for seeding, development of cumulus cloud models for weather modification, and a joint project with the Air Force for seeding cumulus clouds. Experiments continued for dissipating warm clouds by heat sources and helicopter backwash. Continued efforts to develop operational methods for clearing warm fog and stratus, and to improve existing techniques for clearing supercooled fog. Continued investigating methods for preventing high electrical fields in cumulus clouds (lightning suppression).

Navy: Carried on with the development of pyrotechnic as well as other fog and cloud treating devices; conducted both theoretical studies and field experiments to develop improved treatment techniques. With the Department of Agriculture, expanded instrumentation of the jointly developed seashore test site for study of advection fog. Continued its participation with ESSA (now NOAA) in Project Stormfury, with major attention devoted to systematic exploitation of conditions under which tropical cyclones are susceptible to modification.

Air Force: With the Navy, continued different approaches to development of the automated airborne instruments needed for making fine-scale measurements of cloud drop sizes, and producing these data in a computer-compatible output format. Activity focused on dissipation of fog and low stratus.

Fiscal year 1972

Army: Field studies concentrated on the modification of warm fog and were conducted jointly with the Navy, Air Force, and National Oceanic and Atmospheric Administration (NOAA). Investigations of atmospheric electrical structure near cumulus clouds and related modification possibilities were continued. The Army continued its participation in the National Hail Research Experiment (a project in hail suppression).

Navy: Warm fog and tropical storms continued to be the primary targets of the Navy's weather modification research effort. Emphasis continued on laboratory and field tests of nucleating materials, and methods of dispersal. Computer models of fog and convective processes were updated and improved through incorporation of laboratory and field experimental data.

Air Force: Results of warm fog modification experiments conducted in California during Jan. 71 were evaluated with an eye toward a larger test to be conducted in 1972. The purpose was to evaluate promising warm fog modification techniques and consider new approaches toward dispersing this operationally restrictive condition.

Fiscal year 1973

Army: Studies will continue to acquire a better understanding of the physical processes in the atmosphere which cause the formation, growth, and dissipation of clouds, fog, and rain, with emphasis on warm fogs. Development of numerical models describing the life cycle of natural radiation fog and describing various methods of modification of radiation and advective fog will be continued. Field studies will concentrate on the dispersal of warm fog by helicopter downwash to obtain the information required to define the limits of this technique. Development of a mobile propane dispenser for dissipation of local supercooled fogs will continue. Investigations of atmospheric electrical structure near cumulus clouds will be continued.

Navy: Warm fog and tropical storms continue to be the primary targets of the Navy's weather modification research effort. Emphasis will continue on laboratory and field tests of nucleating materials, and methods of dispersal. Computer models of fog and convective processes will be updated and improved through the incorporation of laboratory and field experimental data, and new empirical and theoretical results. Development efforts will continue on instruments and methods for studying natural cloud processes and for evaluating experiments.

Air Force: Full-scale field tests of the airborne hygroscopic particle seeding techniques of warm fog dissipation will be conducted at an Air Force base on an

operational basis. A pilot study using a ground-based heated-plume technique to dissipate warm fog will be conducted at Vandenberg AFB, California.

NOTE.—Source documents for the information given above are: Interdepartmental Committee for Atmospheric Sciences Report No. 14, January, 1970; Interdepartmental Committee for Atmospheric Sciences Report No. 15, March, 1971; and Interdepartmental Committee for Atmospheric Sciences Report No. 16, May, 1972.

PART II

Examples of Department of Defense R&D Field Tests and Evaluations in Weather Modification.

Fiscal year 1968

Air Force:

1. Project WARM FOG, conducted at Travis AF Base, Calif.: project initiated to determine the feasibility of using jet engines for the quick-reaction dissipation of fog.

2. Project COLD FOG III, conducted at Wiesbaden AB, Germany: no tests were made under the project since no persistent supercooled fogs occurred at the base. However, COLD FOG I and II had previously made use of dry-ice cakes suspended in tethered balloons to initiate crystallization in the supercooled fog.

3. Project COLD WAND, conducted at Fairchild AFB, Washington: project tested use of liquid propane as a cooling agent in fog modification; the technique has been used operationally at Orly Airport, France since 1964.

4. Project COLD HORN, conducted at Grafenwohr AI, Germany: project tested a fog-modification technique using vented liquid carbon dioxide (CO_2) as the glaciating agent.

5. Project COLD FAN, conducted at Kingsley Field, Oregon: project tested using a carbon dioxide dispenser in both stationary and mobile configurations in dispersing supercooled fog.

6. Project COLD COWL, conducted at Elmendorf AFB, Alaska: tested the use of crushed dry ice dropped from an aircraft in dissipating supercooled fog.

NOTE.—See Air Weather Service Technical Report 209, dated November 1968, attached, for further details.

Navy: Continued cloud physics studies; progress in engineering weather modification experiments by computer modelling; participation in PROJECT STORMFURY was limited by a dearth of tropical storm activity.

Fiscal year 1969

Air Force:

1. Projects continued from FY 68, viz COLD COWL and COLD WAND.

2. Project COLD CRYSTAL in Europe, conducted at Hahn, Bitburg and Spangdahlem Air Bases, was very similar to Project COLD COWL in Alaska; aircraft dispensed crushed dry ice to dissipate supercooled fog.

3. Project COLD PLUME was conducted at Kinglsey Field, Oregon: liquid propane was dispensed from ground-based trailers for dissipation of supercooled fog.

4. Project COMBAT WARM; tested dispersal of tiny hygroscopic particles from a ground-based blower to dissipate warm fog; as the particles fall to earth, they absorb and remove moisture from the fog layer. Sodium nitrate ($NaNO_3$) was used as the seeding material.

NOTE.—See Air Weather Service Technical Report 213, dated June 1969, attached, for further details.

Navy: Continued cloud physics studies at the Naval Research Laboratory: continued to develop computer models which describe the basic physical processes important to weather modification research (experiments can thus be conducted on a sound engineering basis); had highly successful participation with NOAA in PROJECT STORMFURY.

Fiscal year 1970

Air Force: Project COLD WAND continued at Fairchild AFB, Wash.; Project COLD COWL continued at Elmendorf AFB, Alaska; and Project COLD CRYSTAL continued at Hahn, Bitburg and Spangdahlem AB in Germany. (See Air Weather Service Technical Report 236, dated August 1970, attached, for further details).

Navy: Cloud physics investigations continued at the Naval Research Laboratory; computerized investigations focused on the use of hygroscopic materials, heat, and helicopter mixing as means of fog dissipation; continued efforts in

theoretical and laboratory research, field tests and evaluations, and engineering development of hardware items. (See A Summary of the U.S. Navy Program and FY 1970 Progress in Weather Modification and Control, dated December 1970, attached, for further details.)

Fiscal year 1971

Air Force: A total of 6 projects were carried out: 4 to dissipate supercooled fog, 1 to dissipate warm fog, and one to increase precipitation.

Project	Location	Mode	Agent
Cold Wand	Fairchild AFB	Ground based	Liquid propane.
Cold Flake	Hahn AB	do	Do.
Cold Cowl	Elmendorf AFB	Airborne	Crushed dry ice.
Cold Crystal	Germany	do	Do.
Warm Fog	McClellan AFB	do	Hygroscopic solution.
Cold Rain	Texas	do	Silver iodide flares.

NOTES

A complete description of each of these projects can be found in Air Weather Service Technical Report 244, dated April 1972, copy attached.

Navy: Projects described for fiscal year 1970 above continued.

A complete description of the Navy effort can be found in "A Summary of the U.S. Navy Program and fiscal year 1971 Progress in Weather Modification and Control, dated January 1972, copy attached.

Project Cold Rain: This U.S Air Force project was conducted in June 1971 and formed a part of a large Texas drought-relief program directed by the Bureau of Reclamation. Supercooled cumulus clouds were seeded with silver-iodide nucleating material to increase rainfall (over what would have occurred naturally) in as wide a geographic area as possible. Air Force WC–130 aircraft were used as seeding platforms for Project Cold Rain.

NOTE.—A very complete description of Project Cold Rain is contained in the attached copy of Air Weather Service Technical Report 245, dated December 1971.

Project Gromet II: Gromet II was a rain enhancement project undertaken in the Philippine Islands at the request of the Philippine Government toward the end of a period of severe drought. The U.S. Air Force had operational responsibility for Gromet II, and the U.S. Navy Naval Weapons Center provided technical direction. Between 28 April and 18 June 1969, 58 seeding missions were conducted. Each had as its primary objective the production of useful rain. The project was successful and the Philippine Government expressed official appreciation.

NOTE.—A very comprehensive description of Project Gromet II is contained in the attached copy of Naval Weapons Center Technical Publication 5097, dated May 1971, entitled "Gromet II, Rainfall Augmentation in the Philippine Islands."

Lists of enclosures:

1. Air Weather Service Technical Report 203 (USAF) dated May 1968.
2. Air Weather Service Technical Report 209 (USAF) dated November 1968.
3. Air Weather Service Technical Report 213 (USAF) dated June 1969.
4. Air Weather Service Technical Report 236 (USAF) dated August 1970.
5. "A Summary of the U.S. Navy Program and FY 1970 Progress in Weather Modification and Control" (Navy Weather Research Facility) dated December 1970.
6. Air Weather Service Technical Report 244 (USAF) dated April 1972.
7. "A Summary of the U.S. Navy Program and FY 1971 Progress in Weather Modification and Control" (Environmental Prediction Research Facility) dated January 1972.
8. Air Weather Service Technical Report 245 (USAF) dated December 1971.
9. "Gromet II, Rainfall Augmentation in the Philippine Islands," Naval Weapons Center Technical Publication 5097, dated May 1971.
10. "Project Foggy Cloud III, Phase I," Naval Weapons Center Technical Publication 5297, dated April 1972.
11 Project Stormfury Annual Report 1970, Dept. of Naval/Dept. of Commerce, dated May 1971.

(Enclosures referred to are in the Committee files.)

COORDINATION WITH STATE DEPARTMENT

Do you coordinate with the State Department in your weather modification activities, such as in the Azores? You do that with the State Department, I presume.

Mr. FORMAN. In fact, as I indicated, the request of the Government of Portugal was made through diplomatic channels, and the message back to the Portuguese Government was a State Department message.

IMPORTANCE OF WEATHER MODIFICATION AS OFFENSIVE STRATEGY

Senator PELL. What importance is attached by DOD to weather modification as an offensive strategy?

Mr. FORMAN. I am not sure I understand the nature of your question, Senator.

Senator PELL. Let me rephrase it more simply. Is there any importance, and, if so, what degree, attached by the Defense Department to weather modification as a means of offensive strategy? In other words, is it of no importance at all as a matter of offensive strategy or is it sometimes contemplated as a means of offensive strategy?

Mr. FORMAN. Mr. Chairman, as you know, and as your recent colloquy with Mr. Pollack has reiterated, the position of the Department of Defense is that it will not comment on operational uses in this area.

Senator PELL. Do you mean will not comment in open session?

Mr. FORMAN. Yes. This is classified.

GENERAL VOGT'S REFUSAL TO COMMENT IN EXECUTIVE SESSION

Senator PELL. I would like to add at this point when General Vogt was here in a classified session of the committee we asked him whether we were engaging in these activities in Southeast Asia and his answer was he couldn't comment in executive session. I think perhaps the real answer is the executive branch won't comment on it in executive session or in open session.

I think the record should show without a violation of confidence that he would not comment in executive session either.

INFORMING OF ARMED SERVICES AND APPROPRIATIONS COMMITTEES

Mr. FORMAN. I think the record should also show, Mr. Chairman, and indeed it does show since you put it into the Congressional Record, the Department of Defense has informed the chairmen of the two Armed Services Committees and the two Appropriations Committees as to the classified nature of certain aspects of our activities in this area.

WHY AREN'T FOREIGN RELATIONS AND FOREIGN AFFAIRS COMMITTEES INFORMED?

Senator PELL. That is true. I think the phrase you used in your letter was, "the appropriate committees," if my recollection is correct. Why aren't the Foreign Relations Committee and the Foreign Affairs Committee appropriate committees to inform of such activities which

obviously cross frontiers? The chairman of the Foreign Relations Committee, to the best of my knowledge, has not been informed. Or would you be willing to correct me on that? I wish you would.

Mr. FORMAN. No; I can't correct you. The letter that Mr. Pollack referred to was of this past March from Mr. Laird to Mr. Cranston, who is a cosponsor of your resolution. It specifies that the chairmen of the four committees I mentioned were the ones who were fully informed.

Senator PELL. I think the letter I received referred to the appropriate committees.

Mr. FORMAN. That was, I think, an earlier letter. This more recent letter is dated March 18.

SHOULD FOREIGN RELATIONS COMMITTEE BE INFORMED?

Senator PELL. Do you not think this would be of concern to the Foreign Relations Committee and they should be informed?

Mr. FORMAN. I am not in a position to answer that question, Senator.

BASIS FOR DOD SELECTION OF COMMITTEES

Senator CASE. What is the basis for the selection of committees by the Department of Defense?

Mr. FORMAN. I can't speak to that, sir. I did not make the selection.

Senator CASE. Could you have an answer provided for the record from the Department of Defense? Have you access to the people in the Department who made that determination?

Mr. FORMAN. Senator, I could take the question back with me.

Senator CASE. Where are you going to take it?

Mr. FORMAN. To the Secretary's office.

Senator CASE. Is it the Secretary with whom you will talk?

Mr. FORMAN. Yes. It is the Secretary who signed the letter I just referred to.

Senator CASE. If it is appropriate, I would like to have that answered. Though I am a member of the Appropriations Committee, I don't think, as such, that puts me in a different status than as a member of this committee. I would like to know the rationale by which the Defense Department assumes the authority to make the selection. Second, I would like to know the rationale which governs the selection.

This is a subject in which I am deeply interested, Mr. Chairman.

(NOTE.—Subsequently the Department of Defense supplied for the record this statement.

RATIONALE OF DOD SELECTION OF COMMITTEES TO BE INFORMED CONCERNING WEATHER MODIFICATION ACTIVITIES

It is not appropriate for a Department or Agency of the Executive Branch of the Government to become involved in jurisdictional issues between Committees of the Congress. The disposition of classified information provided to the Congress through the Congressional Committee of primary jurisdiction over the particular Department of the Executive Branch is a matter for Legislative Branch determination.

Further related to the subject was the following exchange of letters:

SEPTEMBER 14, 1972.

Mr. RADY JOHNSON,
Office of Secretary of Defense for Legislative Affairs, Department of Defense, Pentagon, Washington, D.C.

DEAR MR. JOHNSON: Pursuant to today's conversation between John Marks of my staff and Colonel Harry Dunn of your office, I would be grateful if you could send a reply for the hearing record on S. Res. 281 to the question I asked Mr. Forman on July 26.

Specifically, I would like to know why the Armed Services and Appropriations Committees were chosen, and the Foreign Relations and Foreign Affairs Committees were not chosen to receive information on 1) the overall weather modification program, 2) the tactical application of weather modification in Southeast Asia, and 3) Project Intermediary Compatriot. I would be grateful to learn how such a decision is made, and whether or not the Defense Department would be willing to share the same information with the Foreign Relations Committee now that there is a prospective international agreement concerning weather modification before the Committee.

Sincerely,

CLIFFORD P. CASE,
U.S. Senator.

GENERAL COUNSEL OF THE DEPARTMENT OF DEFENSE,
Washington, D.C., September 21, 1972.

Hon. CLIFFORD P. CASE,
U.S. Senate,
Washington, D.C.

DEAR SENATOR CASE: This is in response to your letter of September 14, 1972, which requests information as to how the Department of Defense determines which committees of the Congress to keep informed of matters pertaining to its administrative responsibilities.

As stated in the insert for the record provided to the subcommittee on September 7, 1972, the Department does not consider it appropriate to become involved in committee jurisdictional issues. As a practical matter however, the Department routinely and traditionally conducts its business on a daily basis with those committees of the Senate and House of Representatives, which under the rules of those two bodies have jurisdiction over the authorization and appropriations for the various functions assigned to the Department. In the functional areas of Operation and Maintenance, Procurement, Research and Development, Manpower, Military Construction and others, the Committees assigned jurisdiction by the Senate and House Rules are the Armed Services and Appropriation Committees.

With regard to your second question, I respectfully refer you to Dr. Foster's letter of December 16, 1971, in response to a similar request by Chairman Pell, a copy of which is attached.

Sincerely yours,

J. FRED BUZHARDT.

Attachment as stated.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., December 10, 1971.

Hon. CLAIBORNE PELL,
Chairman, Subcommittee on Oceans and International Environment, Committee on Foreign Relations, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Your letter of 3 December 1971, which was addressed to the Secretary of Defense, has been referred to this office for reply. In your letter you expressed dissatisfaction with information previously furnished to you by Mr. Rady Johnson on the subject of Department of Defense weather modification activities.

Certain aspects of our work in this area are classified. Recognizing that the Congress is concerned with the question of the military application of weather modification technology I have, at the direction of Secretary Laird seen to it that the Chairmen of the Committees of Congress with primary responsibility for this

Department's operations have been completely informed regarding the details of all classified weather modification undertakings by the Department. However, since the information to which I refer has a definite relationship to national security and is classified as a result, I find it necessary to respectfully and regretfully decline to make any further disclosure of the details of these activities at this time.

Sincerely,

(s) JOHN S. FOSTER, JR.

Senator Case informed the chairman of the committee, Mr. Fulbright, that he considered the information supplied by the Department of Defense to be "nonresponsive" to the questions raised and it was agreed that at a later time consideration would be given to the subject of obtaining an informative response to the question raised.)

Senator PELL. Thank you very much, Senator Case.

As a member of the subcommittee dealing with this subject, I am particularly grateful to you for giving us the time that you have given.

INFORMING COMMITTEE IN EXECUTIVE SESSION ABOUT WARTIME USE QUESTIONED

While the chairmen of those four committees have been informed, your earlier statement that you could inform us on the subject only in executive session is not correct.

Mr. FORMAN. Senator, I didn't understand you to be addressing yourself solely to Southeast Asia when you made that comment. I just don't know the answer when you are talking as possible operational use in wartime.

Senator PELL. But the only war in which we are engaged is in Southeast Asia. When Senator Fulbright asked General Vogt whether we are using it, to the best of my recollection, his answer was that he could not comment on this subject in executive session.

Mr. FORMAN. I am not disputing that, Mr. Chairman; I am merely observing, if I understood your initial question correctly, that you were talking about possible offensive uses in wartime and not confining yourself to the present hostilities in Indochina. It is that on which I am uncertain. Obviously, there are certain things which would be apparent to anyone who might think about the subject as to the possible uses one might make of weather modification. I could speculate as to some of it myself.

I would be hesitant to speculate in open session because I might be getting into areas which are classified. I just don't know. Whether these possible uses, which, as I say, are entirely irrelevant from what we are or not doing in Indochina or might have done, are classified, I am just not certain. I mean I am not certain to what extent they might be revealed to your committee.

POSSIBILITY OF MELTING POLAR ICECAP

Senator PELL. Getting into a few of these possible uses, has the Defense Department ever studied the possibility of what may sound like far-out proposals, though they are not really, such as changing the axis of the earth. Have you ever studied the possibility of melting the polar icecap?

Mr. FORMAN. Senator, I am informed we just don't know how to do much of anything in this area, that we don't know how to modify

the currents of the ocean or the atmospheric currents above us. There are a great many things we just don't know in the geophysical field. The study I mentioned earlier about computer simulation of possible climatic effects or predicting climatic changes—if I may refresh my recollection for a moment—does not deal with how to remove the Arctic ice, but it does go into the question of will we have climatic variations due to major changes on the earth's surface such as the removal of Arctic ice, and to what extent can we predict this on a computer.

As I indicated, I am told by our researchers that our state of knowledge in this area is virtually nonexistent. We just don't know how to do it.

Senator PELL. Have there ever been any field trials or experiments in melting the polar icecap conducted by DOD?

Mr. FORMAN. I don't know this.

Senator PELL. You simply don't know?

Mr. FORMAN. I don't know.

Senator PELL. Could you find out and submit for the record your reply?

Mr. FORMAN. I will check. As I say, I have been informed that our capability to engage in any sort of modification along geophysical lines does not exist.

Senator PELL. Still, would you submit for the record whether or not DOD has engaged in any experiments with regard to melting of the polar icecap. It should not be classified.

Mr. FORMAN. The icecap as such?

Senator PELL. Yes. Could you do that?

Mr. FORMAN. Yes.

(The information referred to follows:)

DOD RESPONSE TO QUERY CONCERNING MELTING POLAR ICECAP

DOD has not engaged in any experiments or field trials to melt the polar icecap.

Senator PELL. That certainly would not have to be classified.

Mr. FORMAN. I should see no reason why it should be as a research project.

Senator PELL. I am trying to keep this as unclassified as we can.

RESEARCH RELATING TO GENERATION OF EARTHQUAKES

What research has DOD conducted relating to the generation of earthquakes, what geophysical activities?

Mr. FORMAN. My understanding is that our research in the field of earthquakes is virtually nil or is nil in the modification sense that you are addressing. We do, of course, do research on earthquakes in a different area. That is the area of the problem of verification, of the Nuclear Test Ban Treaty. It is in that field, in the verification aspect, rather than the modification aspect.

HAS DOD ENGAGED IN WEATHER MODIFICATION OVER CUBA?

Senator PELL. Has DOD engaged in any weather modifications over Cuba?

Mr. FORMAN. I don't know the answer to that question.

Senator PELL. Could you submit that for the record, please?

Mr. FORMAN. Certainly.
(The information referred to follows:)

DOD RESPONSE TO QUERY CONCERNING WEATHER MODIFICATION OVER CUBA

DOD has not engaged in any weather modification over Cuba.

COORDINATION IN ENVIRONMENTAL OR GEOPHYSICAL RESEARCH EXPERIMENTS

Senator PELL. What provision is made for coordination between DOD and State and with foreign governments in the case of any environmental or geophysical research experiments?

In other words, do we let other countries know the results of our seismic research under the Nuclear Test Ban Treaty?

Mr. FORMAN. Yes; generally speaking, the other nations are informed of the results of our research, or I should say of our operations.

OPERATION POPEYE AND INTERMEDIARY COMPATRIOT

Senator PELL. Were Operation Popeye and Intermediary Compatriot coordinated with the State Department? Were they aware of these operations? Could you describe them to us, briefly?

Mr. FORMAN. Senator, all I know of those operations is what I have read in the papers and the Congressional Record in the last 6 months or so, speaking personally.

Senator PELL. This is why we asked Mr. Laird to send us a competent witness.

Mr. FORMAN. Going beyond that, of course, as you have been told by Mr. Laird and by Dr. Foster, the Department of Defense has no comment to make.

Senator PELL. You are right. They told us this, as I said, in both public and private sessions. Would you be free to say whether these operations were coordinated with the governments of the nations involved, Thailand and Laos?

Mr. FORMAN. I can't add to what I have already said. That is the position of the Department.

Senator PELL. Presumably, then, these projects are classified; is that correct?

Mr. FORMAN. I don't wish to even admit, sir, that there were such projects.

Senator PELL. I think the name of the project is public knowledge.

Mr. FORMAN. I have read that statement in the newspapers, but, as you know, the mere fact that something appears in the newspaper does not necessarily mean that the Department of Defense or other Government agencies, as the case may be, will comment on the accuracy of the story. By way of analogy, we are in this area, I think, somewhat in the position that we are with regard to publicity with respect to nuclear weapons, where, as you know, the policy is neither to confirm or deny.

Senator PELL. I don't know whether the executive branch admits to the validity of the so-called Pentagon Papers, but on page 421, volume 4, of the edition put out by Beacon Press of Boston—and I believe they have been reprinted by the Government Printing Office—it refers

to Laos operations "Continue as at present plus Operation Popeye to reduce trafficability along infiltration routes." That is on page 421. You are not free to comment on the validity of that statement?

Mr. FORMAN. No, sir.

WHY CAN'T WITNESS COMMENT ON SOUTHEAST ASIA OPERATIONS?

Senator PELL. If you were free to comment on our operations or nonoperations on the Greenland Icecap or with regard to earthquakes or submit a comment on Cuba, why is it that you cannot comment on any of these operations in Southeast Asia? What is the difference?

Mr. FORMAN. Senator, perhaps my answer was a little elliptical. All I intended to convey was that I would take your questions back to the Pentagon. I am not sure what the response will be. I don't know whether it will be a flat answer or the answer will be that this falls within the previous general statement, with certain aspects relating to national security and classified accordingly.

Senator PELL. Is there any reason why any Member of the House and Senate should be denied information relating to weather modification activities on a classified basis? What is the reason for this wool that we find in this regard? It is extremely frustrating because theoretically we have a certain oversight responsibility. We authorize and appropriate money the use of which we don't always know. Why is it that we are denied either in an open session or in a closed session information with regard to these activities or these nonactivities?

Mr. FORMAN. I am unable to elaborate on the statements which have been made in this regard, Senator.

Senator PELL. Could you give us the reason why you are unable to answer this question?

Mr. FORMAN. Senator, if I am correct in my recollection, both you and Senator Case a little while ago in effect asked that question of me, and I undertook in response to your request to pass it along to the Secretary's office. That is all I can do.

WITNESS' TERMS OF REFERENCE IN ANSWERING QUESTIONS

Senator PELL. Basically, would this be permissible from your viewpoint? What are the terms of reference that have been given to you in answering our questions? On any question in regard to weather modification in Southeast Asia you are not permitted to answer; is that correct?

Mr. FORMAN. Other than what the Secretary has said with regard to North Vietnam.

Senator PELL. He said in answer to a question from the chairman, I believe, that no such activities were being engaged in over North Vietnam. He did not say Southeast Asia. He limited himself to North Vietnam.

Mr. FORMAN. Correct.

MISSION OF OL–2 UNIT AT UDORN AIR FORCE BASE

Senator PELL. Would you be free to comment on the mission of the unit that had the description OL–2 stationed at Udorn Air Force Base in Thailand or would this be beyond your terms of reference?

Mr. FORMAN. I don't know the unit and I don't know whether, if I did know of the unit, it would or would not be within my terms of reference.

Senator PELL. Could I ask you to take that back and submit for the record a brief résumé of the mission of the unit authorized by the Congress and paid for by the taxpayers? In this particular case, if you wish to make it classified, make it classified.

Could you permit yourself to do that?

Mr. FORMAN. I will certainly take back anything the chairman asks me to take back. But I cannot commit the Department of Defense as to the answer, sir.

(The information referred to follows:)

MISSION OF OL–2 UNIT AT UDORN AIR FORCE BASE

(Supplied by Department of Defense)

The mission of the unit is to provide aerial reconnaissance weather data as may be necessary to support 7AF combat operations. In addition, provides storm weather reconnaissance as requested by the Joint Typhoon Warning Center.

Senator PELL. This is one of the reasons why we asked Secretary Laird for somebody who would be able to give these answers.

ACTIVITIES OTHER THAN POPEYE AND INTERMEDIARY COMPATRIOT

If we ask you these questions and there is no comment, we just go through the ritual. In what weather modification activities has the American Government engaged in in Southeast Asia other than Popeye and Intermediary Compatriot?

Mr. FORMAN. The same answer, Mr. Chairman.

HAVE ARMED SERVICES PROVIDED SUPPORT FOR CIA?

Senator PELL. Have the armed services provided support to the CIA for the purpose of carrying on weather modification activities?

Mr. FORMAN. The same answer, Mr. Chairman.

DOES DOD SHARE INFORMATION WITH OTHER CIVILIAN AGENCIES?

Senator PELL. Does the DOD share information concerning its weather modification activities with other civilian agencies?

Mr. FORMAN. The same answer, Mr. Chairman.

WHY DOD RATHER THAN CIVILIAN AGENCIES?

Senator PELL. You mentioned earlier that the armed services have engaged in a number of weather modification operations at the request of and in cooperation with other governments.

Why should such activities be carried out by DOD rather than one of the civilian agencies, such as NOAA or the Department of Commerce?

Mr. FORMAN. I believe I gave one example or one reason in the case of the Azores, as one reason why DOD was doing it rather than others. It might also be that the assets for undertaking the operation which are already in place are those of DOD. Therefore, it would be less expensive for DOD to do it.

COULD WEATHER MODIFICATIONS IN SOUTHEAST ASIA BREACH DIKES?

Senator PELL. Could weather modifications in Southeast Asia, if conducted, produce flooding and breaching of the dikes? That is not saying what we are doing. I am asking if they were conducted could they produce breaching of the dikes and floods?

Mr. FORMAN. I don't think I can go beyond the answer given from a technical point of view to you earlier by Dr. Foster. You are asking me to speculate on the outcome of the state of the art.

I am sorry, the letter I referred to was from Rady Johnson to you, dated November 23, 1971. I would like to read that particular paragraph.

There is no known way to make rain under all conditions. When the proper meteorological conditions prevail, that is, when clouds capable of producing natural rain exist, it is a relatively simple matter to increase the amount of rain which will fall. The amount of rain is frequently of the order of 30 to 50 percent. This augmentation is well within the natural limits of rainfall for regions within which experiments have been conducted. Massive downpours far in excess of natural occurrences have not been produced, and theoretical knowledge at hand indicates that this will probably always be the case.

Similarly, there is no known technique which will permit the steering of storms in a specific area.

CAPABILITY OF DISSIPATING CLOUDS

Senator PELL. In addition to the seeding of clouds producing storms, is it not also a military capability to be able to seed clouds and dissipate them so as to expose the targets for possible bombing?

Mr. FORMAN. Again, Mr. Chairman, we are getting into the area which I indicated earlier I could speculate as could anybody else who thinks about the matter as to possible military applications of weather modification activities.

Since I am not informed as to which of these possible speculative uses might in fact be incorporated into existing planning or contingency thinking, I would prefer not to speculate about the subject lest my speculation be possibly construed as evidence of the fact that we are in fact so planning or thinking.

CONSULTATION CONCERNING CLOUD SEEDING TO DAMPEN DEMONSTRATIONS

Senator PELL. Coming closer to home—and I hope this is not a classified answer—has the Department of Defense ever been consulted regarding the possibility of cloud seeding to produce rain to coincide with antiwar demonstrations around Washington or other cities?

Mr. FORMAN. I don't know the answer to that.

Senator PELL. Could you find that out? Would that fall within your terms of reference? Would you let us know?

Mr. FORMAN. I will let you know.

Senator PELL. On an unclassified basis?

Mr. FORMAN. Well, the answer will certainly be unclassified.

Senator PELL. Right. But the question is: Has DOD ever been consulted regarding the possibility of cloud seeding to dampen demonstrations?

Mr. FORMAN. I presume when you say "consulted," you mean requested by some other Government agency or department?

Senator PELL. Exactly.
(The information referred to follows:)

DOD RESPONSE TO QUERY CONCERNING CLOUD SEEDING TO DAMPEN DEMONSTRATIONS

No such request was ever made to DOD.

RESEARCH CONCERNING PRODUCTION OF ACIDIC RAINFALL

Senator PELL. Has any means been developed to the best of your knowledge, to treat clouds with chemicals that would produce acidic rainfall capable of fouling mechanical equipment, such as radar, trucks, artillery, or antiaircraft weapons? I am not talking about a geographic area, but a general field of knowledge.

Mr. FORMAN. You are talking research now?

Senator PELL. Yes.

Mr. FORMAN. Not use and not operation. I don't know the answer to that question. As I indicated, our research is unclassified. The reports are available.

Senator PELL. I am reading a press report and I wondered if you would comment on its validity. It is to the effect that a method is being developed for treating clouds with a chemical that eventually produces an acidic rainfall capable of fouling the operation, in this case, of North Vietnamese radar equipment.

The question I directed to you was whether the research was being done.

Mr. FORMAN. As I indicated, sir, I don't know the answer to that.

The research, as I have previously said, is unclassified. Our reports are distributed widely through the NTIS (National Technical Information Service) of the Department of Commerce. Certainly, if we have done it, it should show up in the periodic bibliographies.

AVAILABILITY OF WEATHER MODIFICATION RESEARCH

Senator PELL. Is all research in connection with weather modification activities unclassified?

Mr. FORMAN. This is what I have been informed, that all our research is conducted on an unclassified basis and the results of that research is made available to the public.

Let me modify that to some extent. We might conceivably have some research result which is proprietary. For example, if the work were done by some industrial firm, there might conceivably be some technical knowledge which is not classified but yet proprietary to the firm and which might, therefore, not be widely disseminated but made available only on a limited distribution basis to those who are engaged in the field and who are obligated by contract to respect the proprietary rights.

Senator PELL. Would this include the research done at China Lake Research Center?

Mr. FORMAN. So far as I know, it is unclassified in this area.

Senator PELL. In what area?

Mr. FORMAN. Weather modification. As you know, there is other research done at China Lake, which is a naval weapons center.

AVAILABILITY OF DR. ST. AMAND TO TESTIFY

Senator PELL. But the weather modification is unclassified. Dr. St. Amand is the head of that laboratory; is he not?

Mr. FORMAN. I am not sure of his job description.

Senator PELL. He is head of the weather modification portion of it.

Mr. FORMAN. I note from your letter to Secretary Laird that you describe him as the head of the Earth and Planetary Sciences Division of the Naval Weapons Center, China Lake.

Senator PELL. So his work would be unclassified?

Mr. FORMAN. Yes, sir.

Senator PELL. So there is no reason why he could not come up here without any wraps from the administration and be able to tell us freely of his activities?

Mr. FORMAN. I would presume if the questions were confined to the actual research being conducted and the results of the research as distinguished from the possible application of the research in terms of military application, he should be able to testify in that area.

REASON FOR DEFENSE DEPARTMENT MODIFICATION OF RECOMMENDATION 218

Senator PELL. Going for a minute to the recent Stockholm meeting, why did the Defense Department want to modify Recommendation No. 218? What was the reason for that?

Mr. FORMAN. I think Dr. Pollack has indicated the basic reasons. I don't know that I can enlarge upon what he said other than to remind the chairman that, at least so far as I can recall, it is fairly standard language in these treaties to modify these absolute obligations by such words as "to the maximum extent feasible" or "where practicable," and so forth.

If I am not incorrect in my recollection, I believe the Seabed Arms Control Treaty, to which reference has been made, has similar language in its text.

REASON FOR EXECUTIVE BRANCH SECRECY

Senator PELL. I want to return for a moment to the central point that bothers me.

What is the reason for the secrecy of the executive branch in this regard both in executive session and in open session? Why won't they discuss activities of this nature, either to say they are being done or are not being done? I can't get to my own satisfaction the reasons for it.

What we are dealing with here is the question, as Mr. Pollack pointed out, of not just climate modification, which he said we would eschew, but weather modification.

I realize weather modification is not going to change the weather over Chicago 3 days later. But weather modification crosses frontiers. This was made very clear when Secretary Laird said we are engaging in no operations over North Vietnam. You don't have to engage in them over North Vietnam to have an effect.

The general question is: Isn't it generally better to be rained on with rain instead of rained on with bombs? The answer is "Yes, unless the rain produces floods that kill or seeding clears the clouds in order to drop bombs."

It also opens up a Pandora's box of new weaponry. My own thought is when you open this door, when this particular camel get's his nose under the tent of the arsenal of weapons and bores in, there will be many more weapons along these lines that will develop, some of which are outlined in Dr. MacDonald's excellent book. He will be a witness here tomorrow.

We are dealing with the environment, with the climate, which is the property of all citizens everywhere. This flat refusal to comment in this field creates a very bad impression, not only in the minds of the American public but I think of the Congress, too.

In my own 12 years here I don't recall a single area where comment is as flatly refused as this. If we are talking about the creation of rain to flood out the Ho Chi Minh Trail, which may produce floods as well that would be devastating to many of the civilians—if we are doing that, why can't we say so?

We are certainly saying we are dropping weapons that kill now. What is the reason behind the adamancy of the executive department? Can you give me some enlightenment? We have been very patient on the Hill, but there is a tremendous sense of frustration, and it is the right of the public, the taxpayer, to know about it.

Can you give me a little guidance as to the thinking, the reasoning, or the rationale of the Defense Department in saying no comment, or the same comment and refusing to reply in open or private session? Could you give me a little help?

Mr. FORMAN. I regret that I am unable to, sir. I would, however, like to call your attention to the fact that a few minutes ago when you were talking about the general area, you used the word "climate." I presume that was inadvertent.

Senator PELL. I am sorry?

Mr. FORMAN. I said that a few minutes ago in your statement you used the word "climate" in the context of changing the environment, as well as weather modification.

Senator PELL. Mr. Pollack said the United States would not engage in any climate modification activities. What we are talking about here is weather modification, a more tactical as opposed to strategic approach.

Mr. FORMAN. I merely wanted to make that point, sir. I am sure you did not intend to use the word "climate" in the sense that Mr. Pollack used it.

Senator PELL. I didn't. I said I agreed with Mr. Pollack.

Mr. FORMAN. I thought you said we would not comment about "climate."

Senator PELL. I said the Government eschewed the use of climate modification. I accept that. What I am discussing with you is weather modification, a very different subject, as you well know, which is the specific subject of the draft treaty on which I am trying to get a comment from the executive branch of the Government.

I don't talk about climate modification. I talk about weather modification which is a localized use of weather changing for military reasons.

REASON FOR EXECUTIVE BRANCH REFUSAL TO COMMENT

I recognize you are speaking here as an intelligent individual but with certain guidance from the executive branch. However, I don't

think I have ever heard as unresponsive a series of replies in open or closed session really since I have been here on the Hill.

I again would ask you: Could you not give us a little general, broad, philosophical background without being specific on the reason the executive branch refuses to comment in either closed or open session on this subject?

Mr. FORMAN. Mr. Chairman, I repeat, as I said earlier when Senator Case was here, all I can do is take that question back to the Secretary's office for an answer. I am not in a position to respond to it.

Senator PELL. I am deeply aggravated, deeply disappointed and must, I think, really recess this committee with the request for perhaps somebody who can comment. At least that broad comment would be of interest to the American people, and certainly to me, as to why it should be so classified.

I hope we will not continue doing these things. I think it ought to be a matter of public knowledge. If it is in private knowledge we will find the same weapons being used against us. We will find other examples of weather modification or environmental modification being used that will have an effect on our agriculture, our fisheries, our own life here.

WITNESS' INSTRUCTIONS CONCERNING DISCUSSING WEATHER MODIFICATION

I think we should bring these approaches into the open. Rather than saying that this will conclude the appearance of this particular witness, I think I must press you one step further and say are you under instructions not to discuss this subject?

Mr. FORMAN. I am sorry, I don't understand what you mean by this subject.

Senator PELL. This subject being the use of weather modification activities for military purposes in Southeast Asia.

Mr. FORMAN. Yes, sir.

Senator PELL. You are under instructions in that regard?

Mr. FORMAN. Yes, sir.

Senator PELL. Then I really must recess this hearing and ask you to take back the message to the Secretary of extreme disappointment on my part, and on the part of the committee, and hope that a more forthcoming witness, not criticizing you as an individual, but a witness with instructions that will permit him to answer the general questions I have asked, would be forthcoming, or that you could submit for the record such information.

Mr. FORMAN. I understand.

Senator PELL. On that note of frustration, I think I must recess this committee.

If you or another witness care to come back tomorrow, you would be most welcome, particularly with regard to the last question of what is the reason for the refusal of the Department to discuss this.

If a witness will come back tomorrow with that reply in an unclassified form, we will put him on ahead of all the other witnesses. I would hope that he might.

Accordingly, this committee is recessed until 10 o'clock tomorrow morning.

(Whereupon, at 11:55 a.m., the subcommittee recessed, subject to the call of the Chair.)

(Additional questions submitted by Senator Case and responses of the Department of Defense follow:)

ADDITIONAL QUESTIONS SUBMITTED BY SENATOR CASE AND RESPONSES OF THE DEPARTMENT OF DEFENSE

Question 1: The Advanced Research Projects Agency's multimillion-dollar climatological modeling project is unclassified, uses some of the most advanced computer technology in the world, and is available for use by NASA and other civilian agencies. Are any parts of NILE BLUE, now renamed Climate Dynamics, classified? Since its aim is to model the globe's climate—a pheonomenon very much affected by non-military activities as industrial pollution—what is the justification for ARPA's sponsorship of the project? Why shouldn't Climate Dynamics be transferred to a civilian agency?

Answer (a): Are any parts of NILE BLUE (now renamed Climate Dynamics) clsssified? No.

(b): What is the justification for ARPA's sponsorship of the project? Why shouldn't Climate Dynamics be transferred to a civilian agency?

The Soviet Union has invested considerable effort and resources in developing a well organized and extensive program in climate modification research. The Director of the Soviet Hydrometeorological Service has declared that active modification of climate is an objective of this research. A number of specific projects have been proposed to alleviate the harsh Russian climate with attendant benefits to agriculture, navigation, and resource exploitation. These include removal of the Arctic pack ice, damming of the Bering Straits, and diversion of Siberian rivers.

These programs clearly might affect the climate of other parts of the world, including the United States and its allies. Even marginal changes in temperature and rainfall could drastically damage agriculture, shipping, and indeed the entire economy. Military operations would also be impacted if the boundaries of pack ice, the ice-free seasons of naval bases, the frequency of obscuring clouds, etc. were altered. Thus climatic changes are clearly potentially grave threats to national security, and have consequent implications for military planning.

For these reasons, it is incumbent upon the DOD to develop a capability to predict the climatic effects of foreign actions and to detect modifications which may be in progress. With a scientifically credible detection capability, world opinion and the instruments of national power may be mobilized to reverse actions damaging to the national interest. These specialized national security questions are incompatible with the missions of the civil agencies, whose meteorological programs center on weather prediction and basic research in atmospheric physics.

Question 2: Has the Department conducted any detailed studies on the long-range effects of extensive weather modification activities?

Answer: No.

Question 3: In your statement, you stated the Department of Defense's field research and development efforts are "usually joint efforts." Could you name and describe the projects which are not joint efforts?

Answer: See attachments to insert on page 37.

Question 4: Is there any classified weather modification research going on at present? If so, what is its extent, its budget, and its purpose? Do the China Lake Naval Ordnance Laboratory, or the Air Force Cambridge Research Laboratories play a role? If so, what is it?

Answer: No classified weather modification research is being conducted.

PROHIBITING MILITARY WEATHER MODIFICATION

THURSDAY, JULY 27, 1972

UNITED STATES SENATE,
SUBCOMMITTEE ON OCEANS AND
INTERNATIONAL ENVIRONMENT OF THE
COMMITTEE ON FOREIGN RELATIONS,
Washington, D.C.

The subcommittee met, pursuant to recess, at 10 a.m., room 4221, New Senate Office Building, Senator Claiborne Pell (chairman of the subcommittee) presiding.

Present: Senators Pell and Case.

Senator PELL. The Subcommittee on Oceans and International Environment will come to order.

OPENING STATEMENT

In opening our hearing this morning on this subject, I would like to read into the record a letter which I wrote Secretary Laird yesterday. It reads as follows:

DEAR MR. SECRETARY: You no doubt have been informed that I felt compelled this morning to recess the hearing of the Subcommittee on Oceans and International Environment because of the nonresponsive testimony of Mr. Benjamin Forman, Assistant General Counsel, International Affairs, of the Department of Defense. The subject matter in question concerned the weather modification activities of the Defense Department in Southeast Asia.

Although Mr. Forman readily discussed aspects of weather modification in which he said the Defense Department had no operational programs, Mr. Forman indicated that he was under instructions not to answer the subcommittee's questions concerning weather modification in Southeast Asia on the grounds of the security classification of the information involved. When asked why such information should be classified, or why the restrictions had been placed upon his testimony, Mr. Forman found himself unable to respond. Accordingly, I recessed the hearing and asked Mr. Forman to relay to you my request that he return to the subcommittee hearing tomorrow with answers to my questions or that some other Defense Department witness appear who could explain the reason for invoking security classification.

The explanation for the extraordinary secrecy with which this subject is treated by the executive branch is a complete mystery to me. The fact that the United States has engaged in weather modification in Southeast Asia is no longer a secret. On what basis can the Defense Department openly discuss its bombing operations in North Vietnam and at the same time invoke secrecy in the case of weather modification?

I sincerely hope that you will send a representative to tomorrow's hearings to address the questions left unanswered today. As I informed Mr. Forman, the subcommittee will arrange for your representative to appear at the outset of tomorrow's hearing.

There have been various telephone calls back and forth. At last report there would be no witness coming up today. Am I correct? Is anybody from the Defense Department here?

(No response.)

Senator PELL. No. So I want to read that letter into the record and reexpress my shock and concern and, really, indignation at the way we are apparently engaging in these activities and cloaking them in secrecy and not commenting on them. As was brought out yesterday, we will not comment on them as a Government either in open session or closed session. So I imagine this seems to be one of, I hope, a small number of activities on which the Congress is supposed to be absolutely uninformed except for the four chairmen of the Armed Services and the Appropriations Committees. I understand there are inquiries being made through the press. The information that reaches them is not as complete as it might be.

I would add that we will resume these hearings any time the Defense Department finds itself in a more responsive mood.

Today we continue our hearings on Senate Resolution 281, which expresses the sense of the Senate that the United States should seek the agreement of other Governments to a proposed treaty prohibiting the use of any environmental or geophysical modification activity as a weapon of war.

Yesterday the Defense Department witness admitted that he had been instructed not to answer any questions concerning military weather modification operations in Southeast Asia. This response reinforces my own belief that the United States is, indeed, utilizing weather modification techniques as a weapon of warfare. Such action may cause irreparable damage to our global environment and could undermine existing peaceful scientific projects, such as the global atmospheric research program and the world weather watch.

I sincerely hope that the administration will reconsider its position on this issue of environmental warfare before more damaging precedents are set.

I know that a number of the distinguished witnesses here today share this view, and I am looking forward to hearing their testimony.

Our first witness today is my own colleague in the Congress, Congressman Gilbert Gude. Is he here?

HEARING PROCEDURE

Welcome, colleague, to the session. I would add the witnesses can make their plans accordingly. I understand that Dr. White has a pressing engagement afterward, and I hope Dr. MacDonald would forgive me if I ask Dr. White to come in ahead of him.

STATEMENT OF HON. GILBERT GUDE, A REPRESENTATIVE IN CONGRESS FROM THE EIGHTH CONGRESSIONAL DISTRICT OF THE STATE OF MARYLAND

Mr. GUDE. Mr. Chairman, it is a distinct privilege to appear before this subcommittee. You, Mr. Chairman, have a remarkable record of sponsoring arms control measures, particularly the Seabed Treaty, for which we owe you so much. It is encouraging, therefore, that this committee is considering the challenge to good sense and arms control raised by the specter of geophysical warfare.

I have served for almost 2 years as Chairman of the World Environment and International Cooperation Committee of Members of Congress for Peace through Law—MCPL. MCPL is a bipartisan, bi-

cameral association of 32 Senators and 101 Congressmen. Together with Senator Alan Cranston, our committee's Vice Chairman, we have been investigating the military use of weather modification since March of 1971.

I have noted that you will hear from a number of eminent scientists today, and that yesterday you were briefed by administration spokesmen, such as it was. I will leave the technical details of this new form of warfare to these experts. I do want to explore, however, three major areas of my concern over the development and use of environmental warfare techniques: The arms control implications, the effects on the U.S. scientific community, and the environmental consequences.

ARMS CONTROL IMPLICATIONS OF ENVIRONMENTAL WARFARE TECHNIQUES

Concerning arms control implications, it appears that this country has precipitously blundered into a most unwise use of technology. The arms control implications are staggering. As Senator Cranston and I pointed out to the Secretary of Defense on June 15, 1971;

> Using weather modification as a military tool opens the door to a vast unknown category of warfare. Although techniques are primitive today, experience with other military systems suggests that refinements inevitably will come."

We are taking a step that demands gifted foresight and prophecy beyond our powers. For this reason alone, caution—even abstention—should be our guide.

COMMAND AND CONTROL PROBLEMS

Why should we be so alarmed about a technique that is not nearly as lethal as other forms of warfare? There are several reasons: First, there are distinct command and control problems associated with geophysical warfare and weather modification in particular. We simply do not have effective short- or long-term control over the climates of the world. We can create certain disturbances, but as civilian experiments have shown, control is not very precise. In a military environment, control over the results of weather experimentation is even more uncertain.

The command problem is no less acute. Since the technology to date does not involve great expense or sophisticated equipment, it is not difficult to imagine the use of weather modification by many different military subunits. In fact, there have been reports that we have trained the South Vietnamese to use weather modification. There are no double-key safing mechanisms here, no exclusive possession as with nuclear weapons.

POTENTIAL INDISCRIMINATENESS

We must also consider that the use of weather modification is potentially indiscriminate. Unlike other weapons, the winds and seas are not so directable that we can discriminate between one target and another. By their nature, they are areawide weapons. We cannot flood only military targets or cause drought in areas producing only military rations. The technology will be used against people regardless of their uniform or occupation. Weather modification will inevitably strike civilians harder than nearby military objectives. Will rain along the Ho Chi Minh Trail succeed where years of bombing has not?

And what price will it exact from the agrarian societies along its path, both friend and foe?

DIFFICULTY OF DETECTION

The issues of command, control, and discrimination highlight another disturbing characteristic of weather modification, the difficulty of detection. Unlike other weapons, it may be possible to initiate military weather modification projects without being detected. In other words, the military results may not be visibly tied to the initiating party. This raises the possibility of the clandestine use of geophysical warfare where a country does not know if it has been attacked. The uncertainty of this situation, the fear of not knowing how another country may be altering your climate, is highly destabilizing.

POSSIBILITY OF FALSE CHARGES

I can also envision another possibility. Suppose, for example, that a U.S. plane flys a routine, nonmilitary mission near Chile, Egypt, or Tanzania and by some quirk of fate a major earthquake, flood, or forest fire occurs in one of these countries. Because we have been tinkering with geophysical warfare, we could be charged with creating that environmental calamity due to the mere proximity of the U.S. aircraft. Propaganda would echo around the world. There is ample precedent for believing that this could happen. We need only remember the incident during the Korean war when the North Koreans unjustly claimed that we were using poison gas.

ADMINISTRATION LEADERSHIP IN ARMS CONTROL FIELD

The administration has shown great leadership in the arms control field. SALT and the ban on biological weapons are two excellent examples. It is to this record that we should look for a model to follow.

There are certain parallels between weather modification and the early use of chemical warfare in Vietnam. Then, as now, we did not know the long-term consequences of our actions. We are only now beginning to understand how profound was our effect on the Vietnamese ecology. We cannot afford to repeat this experience. Therefore, I propose that the President's initiative in the biological field could be used as a relevant model for restrictions on geophysical warfare.

CONSEQUENCES OF MILITARY ENVIRONMENTAL WARFARE ON SCIENTIFIC COMMUNITY

Mr. Chairman, my second area of concern deals with the consequences of U.S. military environmental warfare on the U.S. scientific community. Geophysical warfare can poison the atmosphere surrounding legitimate international programs such as the global atmospheric research program, the international hydrological decade and meteorology in general. We have already seen that it caused the U.S. delegation at the Stockholm Conference to water down a recommendation on climatic changes. The potential for embarrassment is great and for that reason Senator Cranston and I conducted our

correspondence with the Defense Department in private for over a year until the issue broke in the press.

Our scientific community could come under suspicion or attack at these international meetings. The trust built over the years by our excellent atmospheric scientists could be dispelled in one stroke of Pentagon experimentation. For this reason, it is of paramount importance that the Secretary of Defense publicly divorce all U.S. military weather modification or geophysical research activities from civilian organizations.

The U.S. Forest Service already has been drawn into the Vietnam conflict and in a most disturbing manner. Who would have thought that the same agency that teaches "Help Smoky stamp out forest fires!" would be contracted by the Pentagon to help create firestorms in Vietnam. It is a sign of the pervasive influence of this mistaken war.

ENVIRONMENTAL CONSEQUENCES OF WEATHER MODIFICATION

In recent years we have come to realize that many of our activities in society have undesirable environmental consequences. Too often we learn of these after much of the damage has been done. The area of weather modification has potential for causing considerable environmental harm and I regret the fact that the public has been kept ignorant of what developments are taking place.

The Department of Defense has testified that it is conducting a study of climate modification known as Project Nile Blue. Under this study a sophisticated computer called the Illiac IV will further advance our technological knowledge of how to change weather patterns. Obviously, such knowledge can be used for offensive military purposes.

Today there exists the strong likelihood that we have artifically increased rainfall in Indochina. Obviously, this activity can be significantly destructive. Floods and intense downpours can do more than hinder troop movements; they kill people and they destroy property.

Such operations are still at a primitive stage; however, beyond making rain, we just look to the possibility of prolonging droughts, redirecting storms and hurricanes and setting off earthquakes with small nuclear devices. Even the possibility of permanently changing the world's climate by tampering with the polar ice cap is no longer in the realm of science fiction.

We learned at the dawn of the atomic age that no military potential will long remain in the sole control of one power. It may be possible, for example, that as the Soviets develop their computer technology their weather control technology will progress correspondingly. But we should not be forced into this field due to some possible Soviet interest and neither should we encourage the U.S.S.R. to increase its capability because of our experimentations. It is in the best interest of both countries to avoid a technology race that could culminate in environmental disasters.

Many authorities have testified that weather modification is a Pandora's box. This is true in more ways than one. We not only do not know how far our technology will take us, but we also have no idea of what may be the permanent consequences of the experiments we have conducted so far. The top secret acidic rain, produced by the

so-called hydroscopic seeding, is a prime example. Has it changed the acid content of the soil? Does it destroy plant life or alter the ecosystem of the area on which it falls?

ABSENCE OF NATIONAL POLICY ON WEATHER MODIFICATION

In the exchange of correspondence with the Department of Defense, Senator Cranston and I repeatedly inquired about U.S. national policy regarding weather modification. In one reply we were told that weather modification has been discussed in DOD for some 20 years. It probably goes back even further, for during World War II we solved a fog problem at Iwo Jima airport by blasting the top off a nearby hill. Regardless of the time span, the most startling point is that only recently has an Under Secretary's committee been convened to formulate a definitive national policy. Twenty years or more we have been moving toward a new form of warfare with no overall policy guidance. Deputy Director of Research and Engineering, John S. Foster, has said that "Presumably this policy when completed will be announced to the Nation in some appropriate fashion."

I think we have all waited too long. I must also note that the Pentagon has been most uncooperative in our search for answers. They have decided to keep this aspect of our Vietnam policy secret from the public and from Congress except for one or two committee chairmen.

RECOMMENDATIONS

In light of the potential embarrassment and environmental hazards involved in geophysical warfare, I have three firm recommendations:

First, I recommend that all geophysical research and development be conducted under open, civilian auspices except disignated defensive military applications designed to save lives. Picking up downed pilots and fog control at airports would be examples of permitted activities. There is no justification for DOD to remain in the business of harnessing the environment for military use.

Second, I recommend that the United States reject all forms of geophysical warfare as of a date certain and request other nations to join in an international treaty to that effect. The model of the biological agreements could well be followed, including a no first-use provision.

Third, I recommend the creation of a civilian oversight board composed of representatives of the National Academy of Sciences—NAS, Environmental Protection Agency—EPA, Department of Defense—DOD, Arms Control and Disarmament Agency—ACDA, Department of Agriculture, Department of the Interior, Department of Commerce—NOAA, NASA, Department of State and a nonvoting representative from the United States Intelligence Board—USIB, to be chaired by NAS, to insure that all environmental research and operations do not have covert military applications and to insure the divorce of military and civilian scientists studying geophysical engineering.

INSERTIONS FOR THE RECORD

Mr. Chairman, this concludes my remarks except to ask that my exchange of correspondence with the Department of Defense be placed in the record at this point, along with the two excellent articles from Science magazine by reporter Deborah Shapley; and a letter to the President jointly signed by the Federation of American Scientists and the Sierra Club.

Senator PELL. Without objection, they will be placed in the record. (See appendix, pp. 103 and 108.)

ARTICLE BY MR. PFEIFFER AND MR. WESTING

Mr. GUDE. I also commend to the committee a recent article appearing in Environment magazine by E. W. Pfeiffer and Arthur H. Westing on the "Environmental Impact of Modern Weapons Technology in Southeast Asia." (See appendix, p. 115.)

Thank you. I appreciate your consideration.

Senator PELL. Thank you very much for a thoughful and constructive statement.

UNJUST ACCUSATIONS

I was particularly struck by the point that we can be accused unjustly of engaging in this kind of activity if we don't open up our present activities. We could be accused unjustly, as you pointed out, if a plane or vessel happened to be in the proximity of a natural disaster somewhere around the world.

S. RES. 281 DRAFT PROPOSAL AS WORKING MODEL

In connection with your second recommendation to the effect that we would join in an international treaty, I was wondering if you had a chance to go over Senate Resolution 281 and what your reaction was to that particular draft proposal as a working model.

Mr. GUDE. I am strongly in support of the general thrust of the resolution, Senator Pell, and would like to submit comments point by point to your resolution.

Senator PELL. I would welcome those comments as I look at this first draft with improvements made in the use of the word "eschew" rather than "prohibit," which, I believe, is a legal connotation that is preferable. I would hope that before too many years have gone by we would see emerging at the United Nations some treaty of this sort.

I thank you very much for coming up and giving us your time.

Mr. GUDE. Thank you, Senator Pell.

Senator PELL. Thank you, Mr. Gude, very much.

The next witness is Dr. Robert White, Administrator of the National Oceanic and Atmospheric Administration, Department of Commerce, a friend and individual whom I admire very much.

Would you introduce your colleagues?

STATEMENT OF ROBERT M. WHITE, ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE; ACCOMPANIED BY DONALD MOORE, ASSISTANT ADMINISTRATOR FOR ENVIRONMENTAL MODIFICATION; AND JAMES BRENNAN, OFFICE OF THE GENERAL COUNSEL, NOAA

Mr. WHITE. I'd be glad to do that, Mr. Chairman.

On my left I have Donald Moore, our Assistant Administrator, Environmental Modification; and on my right is James Brennan of our General Counsel's Office.

I welcome this opportunity to appear before your subcommittee today to discuss the international aspects of weather modification and the possible control of other geophysical processes.

There is no doubt in my mind that we have only just begun to develop the potential for human betterment by the artificial modification of natural environmental processes. Our capabilities for consciously affecting environmental processes are still primitive. Our scientific understanding on which such capabilities are based is limited. Nevertheless, we have reached a point where some of our techniques are useful. This is true in the field of weather control. In other fields, such as earthquake control, only the theoretical possibilities are under examination. Because it is in the field of weather control where the widest spread activity is now going on, I would like to focus my remarks on the status in this field.

ABILITY TO AFFECT PRECIPITATION PROCESSES

What is the nature of the weather control capabilities we now possess? Almost all capabilities are based on the concept of seeding cloud systems with agents such as silver iodide, dry ice or salt, thereby providing nuclei which affect the precipitation processes.

We now have the ability to disperse cold fog where water droplets are below freezing. This technology is widely used at airports around the world where cold fog occurs with some regularity. In the case of warm fog, present experimental techniques have shown some promise, but no reliable and practical warm fog dispersal system now exists. Success with warm fog dispersion can make it possible to deal successfully with the remaining airports having significant fog problems.

We now have the ability to modify rain or snow in certain geographical regions and under certain meteorological conditions. Experiments in Florida with tropical cumulus and with clouds formed on the upslopes of mountains in the West indicate that rain can be increased in a reasonably predictable way when cloud conditions are right. In other types of clouds and in other geographical locations, the results have been mixed and in some cases precipitation appears to have been suppressed when the opposite effect was intended.

As we learn more about precipitation processes, we can look forward to the time when we can deal successfully with a broader range of meteorological phenomena and over wide geographical areas. In time, we should be able to increase precipitation in a predictable manner for the purposes of increasing soil moisture, replenishing reservoirs and the like. As our knowledge expands we can look forward to the time when it will be possible to redistribute precipitation in order to

make more efficient use of the moisture reaching the ground. We can also visualize the possibility that one day our science and technology may enable us to suppress unwanted precipitation. One need only recall the recent Rapid City and east coast flood disasters to realize the tremendous benefits to be derived from such a capability.

However, the full potential of precipitation enhancement, redistribution and suppression will not be realized until we learn a great deal more than we know now about the physics and dynamics of clouds and cloud systems. Improved nucleation theory, better techniques for delivering the seeding agents to the target area, more accurate and reliable instrumentation, carefully designed and controlled field experiments and the development of computer models to simulate the actual microphysical and dynamic changes that take place during seeding, all are needed before we can say we understand the processes involved and can routinely obtain predictable and beneficial results.

HAIL AND LIGHTNING SUPPRESSION

Hail and lightning suppression through weather modification is showing increasing promise. The Russians and French are obtaining results in suppressing hail to reduce crop damage and our U.S. experiments in hail suppression are now maturing. The United States has reported some success with experiments to reduce forest fires through lightning suppression techniques.

MODIFYING HURRICANES AND OTHER SEVERE STORMS

We are exploring the possibility of modifying hurricanes and other severe storms. Theoretical and experimental work in the last decade have placed our approach to these problems on a sound scientific basis with encouraging results. In experiments in hurricane Debbie of several years ago, the maximum winds in the hurricane eyewall were reduced by as much as 30 percent. While this was extremely encouraging, many more such experiments will be necessary to confirm these results as a change of this magnitude is within the natural variability of hurricanes. The benefits of a successful hurricane moderation capability would be tremendous. Hurricanes, typhoons and tropical cyclones bring devastation by wind, flood-producing rain and—most lethal of all—the storm surge. Hurricane Betsy in 1965 ushered in the era of the billion dollar hurricane, causing $1,420,500,000 in property damage—slightly exceeded in 1969 by Camille, with $1,420,700,000 in damage.

In a recent study of hurricane modification, Stanford Research Institute estimates benefits of up to $200 million from moderating single storms such as Betsy or Camille. No dollar values can be placed on the reduction in human suffering that would also result.

EFFECT OF CLOUD SEEDING OUTSIDE SEEDED AREA

Another unknown in weather modification is the effect that cloud seeding may have on weather outside the area undergoing seeding. Some preliminary studies indicate that such an effect may in fact occur. Additional study of this is needed.

INTERNATIONAL INTEREST IN WEATHER MODIFICATION

The potential benefits of weather modification are widely recognized in many nations, and work in this field is spreading. The following countries have active programs to determine means for increasing precipitation when and where it is needed: Australia, Brazil, India, Israel, Japan, Mexico, the Philippines and the U.S.S.R. Countries actively engaged in studying means for dispersing fog include Canada, France and the U.S.S.R. Countries having active hail suppression research programs include Canada, France, Italy, Japan and the U.S.S.R.

Perhaps just as important, many nations are now actively seeking assistance in the use of weather modification techniques to alleviate water shortages and reduce hail-induced crop losses. The United States has assisted these countries in a variety of ways. We have loaned experts who act as consultants to the meteorological agencies of the countries concerned. These experts study the climatology of the area and advise on weather modification techniques and field programs. In other cases, private U.S. weather modification companies have entered into contracts with foreign countries for the purpose of augmenting precipitation and/or suppressing hail. Countries that have received U.S. assistance or have contracted with the U.S. companies in recent years include Afghanistan, Argentina, Brazil, Chile, Cyprus, Ethiopia, Iran, Kenya, Libya, the Philippines and Taiwan.

International interest in weather modification is high and growing. But such common interest in weather is not new. The nations of the world depend upon one another for weather data. Storms move across national boundaries and all countries depend on one another to be forewarned of these events. Weather has been a binding international force and traditionally it has been an area of almost selfless collaboration among nations. To coordinate the international data exchanges and other meteorological activities, the United Nations has established the World Meteorological Organization (WMO). The WMO and its predecessor organization, the International Meteorological Organization, date back to 1873.

NEED FOR INTERNATIONAL COORDINATION AND COOPERATION

Now that certain kinds of weather modification are a reality, it is possible for actions in one country to affect the weather of another. The potential for conflict is immediately apparent and the need for international coordination and cooperation becomes vital if we are to make progress and realize the potential benefits of this technology. International cooperation in weather modification is of long-standing. The WMO has considered the subject of international weather modification for two decades.

The need for international cooperation is illustrated by Project Stormfury, a program designed to investigate the feasibility of reducing the intensity of hurricanes. The program is a joint Department of Commerce/Department of Defense endeavor and is coordinated with foreign countries in the operating areas by the State Department. This program has been in continuous operation in the Gulf, Caribbean and Western Atlantic since 1962. We are hopeful of moving the experiment to the Pacific in a few years to enable us to

experiment on more storms and in a larger area. The cooperation of countries such as the Philippines, Japan, Taiwan, Korea and the Peoples Republic of China will be indispensable to this experiment, inasmuch as the typhoons involved in the experiment will probably eventually enter one or more of these countries.

FORMS OF INTERNATIONAL COOPERATION

International cooperation takes many forms. Much of the useful exchange is outside governmental channels on a scientist-to-scientist basis. It also results from bilateral and multilateral agreements. A good example of the latter is the exchange program with the U.S.S.R. On behalf of the United States, NOAA sponsored an exchange in the field of weather modification in 1969 with the Soviet Hydrometeorological Service under the U.S./U.S.S.R. exchange agreement. A six-man U.S. delegation visited the Soviet Union for 4 weeks in May of 1969 and the Soviet delegation returned the visit in the fall of 1969. As a follow-up to this exchange, the National Center for Atmospheric Research and the Hydrometeorological Service of the U.S.S.R. are exchanging visits this year in the field of hail suppression.

U.S. DEPENDENCE ON OTHER COUNTRIES' COOPERATION

I cite these examples to illustrate that the United States depends on the cooperation of other countries for the furtherance of its own weather modification programs. The research and experimentation going on in all countries are contributing daily to our knowledge of weather modification. This open exchange of information will be increasingly important as the science advances worldwide. To insure the continued advancement of weather modification research and development, and to apply this technology for human benefit, the United States must conduct its civilian programs with maximum openness and within the framework of specific safeguards designed to protect the interests of the United States and of other countries.

SENATE RESOLUTION 281

Mr. Chairman, to this point I have focused my remarks exclusively on the status and international apsects of weather modification. I would now like to turn to Senate Resolution 281. Our views on the proposed treaty have been given by the Department of State. There are, however, two points concerning the resolution that I wish to note.

First, in my view, it is not possible to draw clear distinctions between research and technological development on weather modification for hostile and nonhostile purposes.

The second point I wish to make concerns the state of our knowledge regarding environmental and geophysical control. The question arises as to whether we know enough about artificial interference with the forces of nature to consider a meaningful treaty at this time. I have already discussed the limited nature of our knowledge of weather modification.

We do not fully understand the full impact on the long-term climatic changes now taking place in the earth's atmosphere due to the activities of man or as a result of natural causes—for example, volcanoes. We

know very little about the possibilities of inducing lasting climatic change as this knowledge depends to a large extent on research now being carried out on the general circulation of the atmosphere and the interaction between ocean and atmosphere.

As I mentioned earlier, earthquake control must be considered far in the future. A few experiments indicate that it may be possible to stimulate small earthquakes along known active faults by injection of a fluid under high pressure through a bore hole, but the extrapolation of this work to the deliberate release of significant energy by an earthquake fault is highly conjectural.

Large-scale modification of the oceans also seems remote at this time.

The concept underlying the proposed treaty is an important one that deserves extensive discussion and further study. However, our knowledge of environmental control techniques must be further advanced before it would be desirable to consider proposal of any treaty.

I will be glad to answer any questions you may have.

Senator PELL. Thank you very much indeed, Dr. White.

I was very struck by the sentence in your statement where you talked about the importance of the openness of the research and experimentation going on and the need to cooperate between nations in this regard.

DESIRABILITY OF PROHIBITING USE OF WEATHER MODIFICATION IN WARFARE

I want to ask you whether you believe it would be desirable to prohibit the use of weather modification in warfare?

I realize that you have put your views into the Department of State as a lead agency and, as you know, they have opposed the pressing ahead with my Senate resolution as of now. But I would like to put to you the more general question as to whether you believe it would be desirable, in our national interest, to prohibit the use of weather modification in warfare, as a general statement, without going into the specifics of this treaty?

Mr. WHITE. Mr. Chairman, I would have to defer, on that question, to those agencies of the Government that are responsible for formulating that kind of national policy. The decisions as to what is in the general national interest on this matter are the responsibility of the Department of State, the Arms Control and Disarmament Agency, and the Department of Defense.

Senator PELL. Right. You were not here, I don't think, yesterday. We had the Department of Defense witness with us and I think in my 12 years here I have never received such a series of replies to the effect that he couldn't reply. He said he was under instructions in this regard. The thing that is so frustrating for this committee is that in private, executive session we also were told that no comments can be made in this field. One is left with the conclusion this is of such paramount national interest, it is so secret, that the Congress is not to be trusted with it, in closed or open session. The Defense Department says it has informed the four chairmen of the appropriate committees. The Foreign Relations Committee is not one. So I am trying to create a general viewpoint or a consensus as to what would be best for the country, and really for humanity, as we move on down the road.

HAS NOAA COOPERATED IN WEATHER MODIFICATION ACTIVITIES IN SOUTHEAST ASIA?

Going back to your own agency, has NOAA cooperated in weather modification activities in Southeast Asia?

Mr. WHITE. No, sir.

Senator PELL. So you would not be directly part of or cognizant of any operations in that part of the world?

Mr. WHITE. I have no knowledge of any of the alleged weather modification activities in Southeast Asia.

Senator PELL. Thank you.

DISCHARGING RESPONSIBILITY WITHOUT KNOWLEDGE OF MILITARY OPERATIONS

Do you think that in your own work you could discharge a responsibility effectively when you are in international conferences without knowledge of whatever military operations we are engaged in in this field? Do you feel inhibited?

Mr. WHITE. Mr. Chairman, I believe that it is likely that the kind of publicity that has now been given to the alleged operations in Vietnam will cause difficulties for us in international conferences where we are discussing meteorology. I say this on the basis of previous experiences I personally have had in international conferences going back a number of years.

For example, some years ago the Soviet Union, on the basis of articles or statements which had appeared, leveled accusations that the United States was planning the military use of weather modification. So I think it would be fair to say that there is a good chance that the kind of attention that has been given to this problem in the press and otherwise will likely give rise to similar kinds of statements in international conferences and will make it difficult for us.

However, I should also say that there is no evidence to date, on the basis of my interactions with other countries, that any of these things have in any way impeded to this point in time our ability to cooperate with these nations on weather modification.

Senator PELL. We were both together at the Stockholm Conference, a really remarkable conference, and, one at which I was very glad to have been with you. We saw the damage that was done to our position by the various environmental activities in which we had engaged in South Vietnam. I would think it would be very much the same kind of circumstance if the weather activities in which we have engaged became established.

PROHIBITING ACTIVITIES BEFORE THEY ARE TOO FAR DEVELOPED

Along the same line, wouldn't it be a good idea to get a treaty prohibiting these activities into effect before they are too far developed? When I worked on the Seabed Disarmament Treaty and we prevented weapons of mass destruction, those weapons were on the drawing boards of the nations involved, the Soviet Union and our own. There is evidence from the excellent articles by Mr. DeSilva and Mr. Hersh and others in the press here that we are engaged in these activities in Indochina. The question I am putting to you is—it is an iffy

question—isn't it better if the weapons are in being to move ahead even faster with some kind of prohibition than if they are just on the drawing board?

Mr. WHITE. Again, Mr. Chairman, I must go back to the point I made previously. I do not feel myself personally qualified to comment on the possible military applications of weather modification and their implication for a treaty, or for how such treaty would be drawn. I would again say I would have to defer to those agencies of our Government who have the responsibility for such matters.

Senator PELL. I understand completely and sympathize with your position. The problem we face is that the executive branch agencies that are responsible decline to inform us and it all seems to move up and up and up, as we understand it, to the powerful and potent Dr. Kissinger, who is the head of the NSC, where these decisions are made.

I believe we will succeed eventually in ventilating this subject and it will become a matter of record.

CAUSE OF RECENT FLOODS IN UNITED STATES

Is there any evidence that the North Vietnamese, the Chinese, or the Russians caused the recent floods in our own northern United States?

Mr. WHITE. None whatsoever. I hope the question, Mr. Chairman, is asked in a humorous vein because this was the greatest disaster ever to strike the east coast of the United States.

Senator PELL. I am well aware of that.

Mr. WHITE. And there is no shred of evidence of any kind of anybody or group tampering with the weather during this circumstance.

FLOODS IN NORTH VIETNAM

Senator PELL. Do you think there is any relationship between the disastrous floods a couple of years ago in North Vietnam and our own activities?

Mr. WHITE. I am not familiar with the details of the flooding there or the meteorological circumstances pertaining to them, so I couldn't answer that question.

PROJECTS UNDER MAY 23 AGREEMENT WITH SOVIET UNION

Senator PELL. You mentioned in your statement a bilateral agreement with the Soviet Union dealing with hail suppression. Could you fill us in with any other weather modification project that would be carried out under the authority of the agreement that was signed by the Soviet Union on May 23, 1972? Are there any others?

Mr. WHITE. Well, we have had rather extensive cooperation. A lot of us have been to their laboratories and have watched their experiments. I have been there myself. We have gained the information that they have. In turn they have been here.

We are presently cooperating in hail-suppression experiments. This is the first time there have been long-term visits and participation by scientists of each side in the activities of the other. In that sense, because of the long-term nature of the exchange, it differs from the previous ones.

RAPID CITY FLOOD DISASTER

Senator PELL. In connection with the Rapid City flood disaster, do you think there is any relationship with the cloud-seeding experiments conducted by the South Dakota School of Science and Technology?

Mr. WHITE. I believe that the analysis that I have seen, prepared under the direction of the Bureau of Reclamation, and also at the request of the Governor of that State, indicates there was no connection between the seeding and that flood.

INCREASED RAINFALL IN EVERGLADES PARK

Senator PELL. When there was some concern with regard to the drying up of the Everglades Park, so near that marvelous installation we struggled to get in Rhode Island but which is now in Florida, there were some cloud-seeding experiments. I was wondering if there is any relationship to these experiments and the increase in rainfall that occurred there?

Mr. WHITE. Well, that was a very serious situation. They had a severe drought there several seasons ago, and we were requested by the Governor of Florida to extend our experimental work, which had been directed at increasing rainfall from cumulus clouds, to see if we could not ameliorate the drought. At that time we did conduct a series of seeding experiments down there. The results indicate that our seeding did have some effect in ameliorating some of the drought in local areas.

GETTING RID OF CLOUDS OVER AIRPORTS

Senator PELL. As I understand it, we are now able to get rid of clouds over airports if they are in warm droplets but not if in cold droplets?

Mr. WHITE. The reverse is true. If the droplets are below freezing, it is possible to get them to crystallize and drop out.

Senator PELL. We have not yet developed a technique for the other?

Mr. WHITE. There are many experimental techniques being used.

SEEDING SYSTEM ABLE TO CAUSE ACIDIC RAIN

Senator PELL. In your statement, you mentioned that most cloud seeding is conducted with agents such as silver iodide, dry ice, and salt. Are you aware of any seeding system that can cause acidic rain? If so, how is this done?

Mr. WHITE. Well, I am not aware of any.

Senator PELL. If there were such a system within the Government, would you be aware of it, or could it be developed outside of your knowledge?

Mr. WHITE. Mr. Chairman, there are many things going on in the Federal Government, of course, that are being done without my knowledge.

Senator PELL. But not in the weather modification field, I would hope, which is your area?

Mr. WHITE. I do not know all of the activities that are going on in the Federal Government in weather modification. I do know all of them that are unclassified. I have access to that information.

Senator PELL. Thank you.

REQUIRING FEDERAL AGENCIES TO REPORT WEATHER MODIFICATION ACTIVITIES

This is a rather technical question. I want to read it carefully so I get it straight:

In 1958, the National Science Foundation was given authority by public law to require all people engaged in weather modification activities to report such activities. Ten years later, in 1968, this authority was repealed in another law. For 4 years, now, no agency or department has such authority. Then a year ago, another law was passed that required all people, all persons engaged in nonfederally sponsored weather modification activities in the United States to report those activities to the Department of Commerce, to your department.

Do you believe that federally sponsored projects should also be required to report to a central point; that is, you?

Mr. WHITE. The legislation as it was written and the rules and regulations that are now being promulgated and are being reviewed through the Federal Register, of course, pertain to non-Federal agencies. However, we are taking steps within the Federal Government to prepare an Executive order that will require Federal agencies to report in exactly the same way.

Senator PELL. I thank you very much indeed, Dr. White, and appreciate your coming very much indeed.

Mr. WHITE. Thank you, Mr. Chairman.

Senator PELL. Our next witness is Dr. Gordon MacDonald, a member of the President's Council on Environmental Quality and the author of a chapter in a remarkable book put out by the Viking Press called "Unless Peace Comes," which I was rereading the night before last. I must say I think it is probably the first scientific description written in terms that a layman like myself can understand of what could happen if we start fiddling with nature, the atmosphere, geophysical conditions, too much. I am very grateful for your coming up and being willing to testify at this time.

Do you have a prepared statement?

STATEMENT OF GORDON J. F. MACDONALD, MEMBER, COUNCIL ON ENVIRONMENTAL QUALITY

Mr. MACDONALD. Yes, Mr. Chairman.

I very much appreciate the opportunity to testify before this subcommittee today on the subject of geophysical warfare, with special emphasis on weather modification and the policy problems it presents to our country.

Senator PELL. Excuse me for interrupting. I think this would be interesting for the sake of the committee record. Without objection, I will ask there be placed in the record the chapter you wrote in this book on how to wreck the environment, page 181 to page 206. (See appendix, p. 124.)

Mr. MACDONALD. Thank you. As I was mentioning, I appreciate this opportunity to discuss geophysical warfare, though I will give special emphasis to weather modification and the policy problems it presents to our country.

In my own view, it is indeed a hopeful indication of things to come that your subcommittee is already addressing itself to this very important issue.

Throughout his history, man has lived totally dependent on the whims of weather. Improper rainfall or sudden flood all too often brought extreme privation and death. Indeed, weather was so important to man as to be a major recipient of his religious attention. But with the benefit of the past 25 years of accumulated knowledge, growth of technology and experimentation, we can now look forward to managing to a limited but important extent this most significant aspect of his environment for the benefit of all mankind.

WHAT WEATHER MODIFICATION IS

What is weather modification? Briefly, it consists of stimulating certain particular meteorological conditions that are capable of producing desired weather phenomena or ameliorating undesirable ones. Thus, while man cannot directly create the weather he wants by brute force, except in such places as the Astrodome, he can in certain circumstances trigger instabilities in the atmosphere to modify existing weather conditions, much as a single shout can sometimes trigger an avalanche. Research in weather modification thus focuses upon identifying these meteorological instabilities, learning how they can be triggered, and understanding the ways they work and the results they achieve.

CONDUCT AND APPLICATION OF WEATHER MODIFICATION RESEARCH

Weather modification research is being conducted and applied in a variety of ways. For some time now, airports have been cleared of supercooled ground fog by seeding the fog with dry ice or silver iodide. One airline has estimated that this procedure has a 5-to-1 payoff of benefits over costs. By contrast, the artificial generation and maintenance of ground fog can be used to protect orchards against frost.

Much of the present effort in weather modification today is being devoted to the objective of clean water augmentation. We now have a substantial amount of experience in understanding the meteorological circumstances under which cloud seeding will increase snowpack on the mountains. In a very real sense, this is banking winter's precipitation. In the spring the snowpack melts and provides the runoff for the river basin area which produces clean water for urban use, electrical power generation, and irrigation. Snow augmentation in the Colorado River Basin is estimated to be able to produce an increase of about 2 million acre-feet of clean water each year. Clean water augmentation can also be done anywhere that nature provides the potential in existing cloud systems. Where rainfall is marginal, an increase of only 5 percent rainfall at the right time of year may mean the difference between crop failure and a bountiful harvest.

AREAS OF RESEARCH NEEDING FURTHER EXPLORATION

Characteristic of young and promising areas of human endeavor, much more research on weather modification is needed. Hail suppression efforts offer attractive research opportunities for example. Ex-

periments performed in the United States have indicated that seeding with silver iodide can measurably reduce hail damage. More extensive work is being done by the Soviet Union where several million acres of farmland are being protected from hail damage by the use of silver iodide injected into critical parts of storm systems by means of artillery shells.

Vitally important research on storms, hurricanes and tornadoes that seeks to discover, understand and exploit these storms' hidden instability weaknesses is being conducted at several governmental and university laboratories across the country and in other nations.

One particularly important area of research that needs further exploration is the modeling of atmospheric processes. Such research is now being conducted on cloud droplet growth, fog, rain and hurricane models and even in modeling the entire earth's atmosphere. This last effort, now being conducted at UCLA, NOAA, the National Center for Atmospheric Research, and other laboratories, is necessary if we are to be able to foresee the downstream consequences of individual weather modification actions.

KEY TO DETERMINING OPTIMUM NATIONAL POLICY

It is this crucial need for more research that is the key to determining the optimum national policy in the area of weather modification over the next several years. The proposed Senate Resolution 281, a rightful recognition of the importance that weather modification will have in the years to come, proposes a treaty that would seek a complete cessation of research, experimentation and use of environmental and geophysical modification activities as weapons of war.

It is important at this early fertile point in the development of beneficial weather modification capability that research in this area be as unfettered as possible. Such a capability, as with most other technical achievements, is essentially neutral. Whether one wishes to encourage rainfall to relieve thirsty croplands or to thwart an enemy objective, the techniques used in either event could be almost identical. Because the fruits of any given research effort can be applied in many ways, the majority of which are often not discernible at the time the research is conducted, the wording of the proposed resolution may well have a dampening effect on the conduct and funding of further scientific studies. Restrictions on research should therefore be weighed very carefully, in view of the potential benefits that weather control offers in terms of lives preserved, crops saved and damage averted.

Weather modification is one of the most important scientific developments now visible on the horizon. If research and applications in this field are properly encouraged and managed, man may soon free himself from stoic acceptance of capricious weather and thereby reap a bountiful harvest of additional crops, new water resources and a safer environment. On the other hand, restricted research and poor public management of environmental applications may cause unforeseen and possibly calamitous consequences. The need for proper and public research and management is clear.

NEED FOR PRIOR ENVIRONMENTAL ASSESSMENT

While I firmly believe that weather modification projects and research should be encouraged and moved forward, I am well aware of the need for appropriate safeguards to protect the environment. Thus, I believe no specific major project to control or modify the weather should be done by the United States for its own benefit or for the benefit of other countries seeking our assistance unless the results of our efforts can be foreseen with reasonable assurance. I believe that the provisions of the National Environmental Policy Act requiring the submission of an environmental impact statement is an appropriate mechanism to accomplish the objectives of assessing the environmental implications of a project and of notifying the public of its potential effects.

The potential for great good or great evil is contained within almost all of man's scientific and technological advances. It is the same with our efforts to escape from the vagaries of the excesses of uncontrolled weather. It is the potential for external harm resulting from blind pursuit of the good that makes careful environmental assessment prior to the implementation a sine qua non for any extensive weather modification program.

I will now be happy to answer any questions that you may have.

Senator PELL. Thank you very much, Dr. MacDonald.

PROGRESS SINCE MR. MACDONALD'S ARTICLE

Senator PELL. In connection with your article, I was wondering if there are any points in it you would like to update? As far as I know, it is the most complete description written for a layman of what can happen when we meddle with the Pandora's box of geophysical modification, although I must add my own interest in this was stimulated not by what was going on in Indochina but by reading the SMIC (Study of Man's Impact on Climate) report. That shocked me so much when I read it I got started on this interest in these hearings and these other things then fell in place, making me realize the importance of what we are trying to do.

Are there any points you would like to make to bring this up to date?

Mr. MACDONALD. Mr. Chairman, I think a great deal of progress has been made over the past 6 years since that article was written in terms of advancing our technology for modifying the weather. The results referred to by Dr. White in terms of seeding tropical cumulus clouds, the increase in our knowledge and capabilities of increasing snowpack in certain mountainous regions, our increased knowledge with regard to the behavior of fogs and increasing knowledge in behavior of warmer fogs, specifically, the increased research in hurricanes, potential modification of hurricanes—all of these are clear advances over the description that I gave a few years ago.

Additionally, I would say that very substantial advances have been made in the areas of earthquake prediction which, in my mind, very likely will lead to the possibility that we might in the future be able to do something about earthquake modification.

The detailed studies of the Denver earthquake and others have very substantially increased our scientific knowledge so that I would expect that in the next few years we will have increased capability in the general area of environmental engineering.

POSSIBILITY OF PRODUCING EARTHQUAKE

Senator PELL. Along this line, to simplify it even further for the record and for those who are here, would I not be correct in my statement that if you have a potential opponent who has the misfortune to have a capital city or resource near one of the major flaws in the earth's surface, that by creating strains, irregularities, explosions, many thousands of miles away in another part of the flaw, we could develop a technique that would produce an earthquake in the enemy's area without his realizing it?

Mr. MACDONALD. As I wrote, this is certainly a possibility. We do not have today the knowledge, the scientific understanding of the mechanism of earthquakes, how earthquakes are produced, to undertake confidently such a project; nor do I think does any other country.

I would point out that in the recently signed U.S./U.S.S.R. agreement, that one specific area for cooperation in the environment was the field of earthquake prediction. The Soviets have had a very active program in earthquake prediction comparable in magnitude and in interest to our program. We felt at the time that agreement was negotiated that this would be an important area for cooperation.

I would also note that a further area for cooperation agreed upon between the Soviets and the United States was the whole question of weather and climate modification. This is included within the environmental agreement.

Senator PELL. So, for the sake of argument, if we had another war with Japan, 100 or 50 years from now, part of the way that war could be fought, since both the west coast of America and the east coast of Japan lie along the same flaw, would be for each of us to research very hard the creation of earthquakes in the other's vital areas?

Mr. MACDONALD. I think it is a possibility; it is certainly a possibility I have speculated on, but I would emphasize that as of today neither we nor the Japanese have a capability in hand nor are we likely to have it in hand in the foreseeable future, that is, in the next couple of decades.

Senator PELL. There is another subject on which I would like to get a little more of your thinking.

POSSIBILITY OF INFLUENCING HUMAN BEHAVIOR

You mentioned brainwaves—the possibility of being able to change the electroimpulses with a harmful or detrimental effect on human beings. Could you enlarge on how that could be developed and what the effect would be?

Mr. MACDONALD. I would say this was by far the most speculative of the various means that one might use in the environment as a potential weapon. The basic notion there was to create, within the cavity between the electrically charged ionosphere in the higher part of the atmosphere and conducting layers of the surface of the earth,

this neutral cavity, to create waves, electrical waves, that would be tuned to the brainwaves; the natural electrical rhythm of most mammalian brains, including man, is around 10 cycles per second, and there are indications that if you tune in at this frequency, that is, these low frequencies of about 10 cycles per second, you can produce changes in behavioral patterns or in responses.

This is a very highly speculative suggestion. The reason I used it in that particular article was to emphasize the point that changes that one can bring about in the environment may have very subtle effects that are not immediately recognized, that even human behavior might be influenced through changing the environmental conditions and that, of course, is why I used it as an example and wish to emphasize the need to really understand what we are undertaking before we go forward with any major environmental modification.

Senator PELL. In view of the rate of growth of man's knowledge, particularly scientific knowledge, these abstract ideas of 4 or 5 years ago may not be abstract when we come to the year 2000, which some of us here may have the good or bad fortune to see, depending in part what we do with this treaty, I think.

Along that line, what would be the effect of brainwaves on human beings? You have described them in your book as having unpleasant effects. What would be the form of unpleasantness?

I realize this is a little esoteric. I am not trying to embarrass you, but I want to make a record here which, if somebody is looking at it in the year 2000 or 1990, makes some sense.

Mr. MACDONALD. As I mentioned, the primitive experimentation conducted primarily on primates in a number of centers would indicate that their actual behavioral characteristics are altered; their responses undergo changes; they do not respond as rapidly when you are tuned in at the proper frequency as if the subject is not exposed to some electrical activity; but as I emphasize in my statement and also in the book, this is indeed a very highly speculative subject.

PROBLEM OF NOT KNOWING WHAT CAN BE DONE COVERTLY

Senator PELL. Right, but one of the problems with this, as with all forms of weather modification, is that one does not know what can be done covertly. That is why I asked the seemingly facetious question if the Soviets, the Chinese and North Vietnamese had anything to do with our disastrous east coast floods. Even if they had, we wouldn't know about it. That is the point here.

CONCERN OVER PROHIBITION OF RESEARCH

Along this same line, I found your statement really very, very forthcoming and interesting, but I also understand your concern over the prohibition of research. This point was brought up yesterday by the executive branch witness, too. I think this is one of the modifications I must make in my treaty.

As I said, this is the first draft and I think it would be improved if we modify it in this regard.

ESCHEWING USE OF WEATHER MODIFICATION IN WARFARE

If the treaty is modified in this regard, what would be your view with regard to the general substance of the resolution, that is, eschewing of the use of weather modification in warfare?

Mr. MACDONALD. Mr. Chairman, as a member of the executive, I would have to defer an answer to that question to the responsible agencies, the Department of Defense, the Department of State and ACDA.

Senator PELL. I understand that. I do not wish to embarrass you. The villain here, I think, is really DOD and NSC.

REVIEW AND CLEARANCE OF WITNESS' TESTIMONY

In this regard, has your testimony been reviewed and cleared by the NSC?

Mr. MACDONALD. Yes, sir.

RESTRICTIONS PLACED UPON WITNESS

Senator PELL. Have any restrictions been placed on you?

Mr. MACDONALD. Yes, sir.

Senator PELL. Thank you very much.

DOD SHARING OF RESEARCH AND OPERATION RESULTS

Does DOD share with the scientific community the results of either its research or operation of weather modification activities around the world?

I am not trying to mousetrap you. That includes Indochina.

Mr. MACDONALD. The unclassified portions of the Department of Defense activities are indeed shared with other nations. They are shared with other agencies of Government through the mechanism of the Interdepartmental Committee on Atmospheric Sciences. I am not privy to any classified work that the Department may have underway or not have underway.

Senator PELL. Would the scientific community be aware of what the defense community is doing in this area in a classified way?

Mr. MACDONALD. Certainly the scientific community, unless they had the proper clearances and the need to know, as determined by the Department of Defense, members of the scientific community would be unaware of any classified activities.

Senator PELL. This is a question of opinion that I am wondering if it would be within your terms of guidance to respond to us.

DESIRABILITY OF MILITARY ACTIVITIES WITHOUT CIVILIAN OVERSIGHT

As a civilian scientist, do you believe it is desirable or undesirable to have the military community engage in research, field experiments, weather modification operations, without the benefit of the scrutiny or oversight of civilian scientists?

Mr. MACDONALD. Well, the situation today certainly in terms of the unclassified activities undertaken by the Department of Defense is that this research is open to public scrutiny, to comment, to review.

Some years ago I chaired a panel for the National Academy of Science that undertook an overall study of weather modification efforts and we looked at what the Department of Defense had underway, looked at it critically, again in the unclassified area.

Senator PELL. But my basic question is addressed to you in your civilian role. In other words, do you think it is a good idea for the military, in classified or nonclassified areas, to engage in such activities without civilian oversight of nongovernment employed scientists? It is a question of opinion I am asking.

Mr. MACDONALD. My opinion is that the unclassified work is being subjected to scrutiny of outside scientists.

Senator PELL. With that I agree. Is it your opinion that it is proper for the classified work to be conducted without outside scientists exercising some oversight over it?

Mr. MACDONALD. Again, since it is an iffy question, it would involve judgments as to the military applicability of whether outside scientists would have competency in this area. It would be an open question and I could not honestly and truthfully give you a blank yes or no answer to that. I think it is a very difficult question and I think one the Defense Department should be particularly concerned about.

RECENT NSC STUDY

Senator PELL. Has the Council on Environmental Quality been involved in the recent NSC study on these subjects?

Mr. MACDONALD. No.

Senator PELL. Do you happen to know if the Environmental Protection Agency was involved?

Mr. MACDONALD. To my knowledge, they were not involved.

SHIFTING EARTH'S AXIS

Senator PELL. Going back to the techniques that could be used, because part of the purpose of this hearing is to inform our people of the various measures that could be used, Jules Verne first wrote and Estes Kefauver later discovered the question of trying to shift the earth's axis, which would have a deleterious effect on many of us in this part of the world and a beneficial effect on some of the more tropical climates. Is this, in your view inconceivable to be done by man or could it be done by man?

Mr. MACDONALD. It just so happens that Walter Monk and I wrote a book about a decade ago called "Rotation of the Earth," in which we used as one of the examples Jules Verne and Senator Kefauver's suggestion, and pointed out the fact that both Verne and Senator Kefauver had forgotten about the earth's bulge, the equatorial bulge which exerts a great stability to the earth's rotational axis. As a result, we certainly do not possess the capability today of producing large shifts in the position of the axis of rotation of the earth.

AREAS OF CONCERN FOR FUTURE

Senator PELL. So the real weapons that we're talking about, which I for one want to see precluded from man's arsenal, would be dealing with precipitation, melting of the ice cap, creation of earthquakes,

stimuli under water and, finally, conceivably, the question of some kind of electrical waves—those four general thrusts.

Do you see any other possible developments in this field of weather modification, geophysical modification, that we ought to be concerned about in the future?

Mr. MacDonald. I think those four general areas cover the field well. Again, in my article I referred to a number of others on which rather substantial research is now being conducted, that is, changing the ozone balance of the stratosphere.

Senator Pell. We were doing this thanks to the SST now.

Mr. MacDonald. As a result of the interest in the SST, we now have a very vigorous research program to determine the mechanisms by which ozones can be depleted or increased within the stratosphere; so I think if you add modification of that part of the atmosphere to our list, it would be a comprehensive list at the present time.

DECREASING OZONE IN ATMOSPHERE

Senator Pell. I read somewhere that the ozone in the atmosphere is being depleted at the rate of .02 percent a year. That would mean, with the proposed use of the SST in the defenses of Russia and America, that we will eventually deplete the atmosphere of ozone. Would that not be correct?

Mr. MacDonald. Again, I would just be on very unsure technical grounds to comment on whether the ozone is indeed decreasing at the present time. I know of reports that ozone levels have been decreasing. Based on our instrumentation capabilities of determining the levels of ozone in the stratosphere, the variability of ozone, and the abundance of ozone, I would seriously question that there is at the present time any long-term trend.

What I find heartening is that even though we do not have a supersonic transport program underway in this country, we do have an extensive research program to find out what the atmospheric effects of SST's on the high atmosphere will be.

REASON FOR CHANGE IN OZONE CONTENT

Senator Case. To the extent that there is a change or depletion of ozone, is it established or reasonably established that it is due to flights by airplanes and other activities of man or not? Or is it due to some other cause, if it exists?

Mr. MacDonald. In my view, there is no convincing evidence that any postulated change in the ozone content is due to man's activity at present.

PREDICAMENT OF CONGRESS

Senator Pell. I have one final, general query.

Do you have any thoughts as to the predicament in which we in the Congress find ourselves? You are a scientist and a pioneer in this book in calling attention to the political dangers in this area. We are Senators also concerned about the impact of weather modification eventually on our own constituents. How can we, the Congress, address ourselves intelligently to this subject, if knowledgeable Government scientists as yourself have to speak out under the wraps that you do? It puts us in a terrible predicament.

Do you have any suggestion as an American citizen how the Congress can become more informed in this field?

Mr. MacDonald. I certainly don't have a suggestion at this time. I very clearly understand the problem that you labor under. In part, for this reason I emphasize the importance of the National Environmental Policy Act in my statement, that this is a mechanism to bring to the public's attention the environmental implications of new technology.

We in the Council on Environmental Quality believe that it is very important that weather modification projects undertaken by the United States undergo the kind of environmental assessment as required by the National Environmental Policy Act, and that these assessments be made public.

Senator Pell. Perhaps this will come out of the little secretariat that is being developed out of the Stockholm Conference eventually. I think we can only hope that will happen.

That is all I have.

Senator Case?

Senator Case. Thank you, Mr. Chairman. I think you and Dr. MacDonald have covered this beautifully.

First, I would like to say that there is scarcely anybody I know of downtown in whom I have greater confidence than Dr. MacDonald as a result of very direct personal connections with his work and his help in certain matters affecting my own State, such as Tocks Island——

Mr. MacDonald. Thank you.

PUTTING WRAPS ON WITNESS

Senator Case (continuing). And other problems of a similar nature.

I was interested in your very frank answer that you were under wraps. Who put the wraps on?

Mr. MacDonald. Senator——

Senator Case. How was it done?

Mr. MacDonald. The typical process of preparing testimony. The individual agencies prepare drafts; these drafts are then circulated to other interested agencies for comment. In this case, the clearance process was handled by the Office of Management and Budget in consultations with the National Security Council. This is not unusual. Every time I have testified as a witness for the administration, I have gone through a similar clearance process.

Senator Case. Well, I was interested in particular as far as the National Security Council's role was concerned. They didn't talk to you directly?

Mr. MacDonald. Members of the Security Council were in contact with me directly; yes, sir.

Senator Case. This is interesting because recently the question has come up as to a comparable agency, recently created or about to be created by statute, and in the President's office, in the field of international economic policy. The question of whether this is an operating agency or staff for the President solely is what I am interested in, and in either case, of course, whether it interposes another layer of insulation between the decisionmaking process and the Congress, and the Congress and the public. That is why I asked the question.

It isn't strange that the Office of Management and Budget should transmit an executive decision, a departmental decision, to everybody, I think.

I think, Mr. Chairman, I don't have any further questions at the moment.

Senator PELL. Thank you.

Thank you very much, indeed, Mr. MacDonald. Perhaps someday when you are translated into a civilian we may again have renewal of our dialog here and develop further the imagination showed in your book.

Mr. MACDONALD. Thank you very much, Mr. Chairman.

Senator PELL. Thank you very, very much indeed for coming.

Our next witness is Dr. Thomas Malone, who is dean of the graduate school, University of Connecticut, member of the National Science Foundation (NSF) Special Commission on Weather Modification, and extremely knowledgeable in this area.

Dr. Malone?

STATEMENT OF THOMAS F. MALONE, DEAN, GRADUATE SCHOOL, UNIVERSITY OF CONNECTICUT, MEMBER, NSF SPECIAL COMMISSION ON WEATHER MODIFICATION

Mr. MALONE. Thank you, Mr. Chairman and Senator Case.

It seems to me that answers to three questions are required to comment constructively on Senate Resolution 281: (1) Has the science and technology of weather modification advanced to the stage at which major issues of national policy are beginning to emerge? (2) Are critical issues of foreign policy involved? (3) Are the treaty provisions of Senate Resolution 281 responsive to the problems and opportunities presented by developments in the field of weather modification?

DEVELOPMENTS OVER RECENT YEARS

Five developments over recent years lead me to the judgment that the answer to the first question is in the affirmative:

1. Understanding of the physical processes in the atmosphere that link one day's weather with the weather on a subsequent day has now progressed to the point at which these processes can be expressed in equations that constitute meaningful mathematical models. These models are increasingly useful in prediction and in simulation, permitting us to seek answers to "what if?" questions.

2. Modern measurement technology, ranging from meteorological satellites for global measurements to Doppler radar for ascertaining some of the relevant physical characteristics of a single cloud, is bringing within reach the kind of observations we need to make sure that our mathematical models approximate the real atmosphere.

3. Advances in computer technology are matching the growing sophistication and complexity of the models and greatly enhancing the powers of these new analytical tools.

4. The accumulating results of field experiments with cloud-seeding techniques have yielded results that, while not rigorously conclusive in all cases, are yearly becoming more persuasive that significant weather control is within reach.

5. There is a growing awareness that a doubling time on the order of a decade or so for population, energy use, and the capability to convert natural resources into goods and services may well be leading us to a situation in which human activity impacts with sufficient force on the atmosphere to produce inadvertent climate modification.

NEW IMPERATIVES IN FOREIGN POLICY

With respect to new imperatives in foreign policy, one of the most prescient comments made was in 1955 by Prof. John von Neuman, cited by Senator Pell in introducing this resolution, in which von Neuman remarked on the need "to develop new political forms and procedures" when "global climate control becomes possible."

I well recall a small meeting convened by Prof. Bruno Rossi of MIT in 1961 at the suggestion of the President's Science Adviser to consider scientific initiatives that would foster closer cooperation among the nations of the world. It was precisely the prospect that man might one day be able to control weather that catalyzed the group and ultimately led to President Kennedy's proposal to the United Nations for initiation of a far-ranging world meteorological program that is even now acquiring structure and gaining momentum. I sought to reflect the views of the community of atmospheric scientists in this country in a keynote address at an International Conference on Cloud Physics in Canberra, Austrialia, when I urged strengthening and unifying international cooperation in atmospheric sciences, adding that "we must recognize the wisdom and prudence of fostering international cooperation while the problem of weather control is a purely scientific one of uncertain outcome. Should this outcome be affirmative, a Pandora's box of scientific and political problems would be opened. Much could be gained; little would be lost by forging the links among scientists and nations that would better prepare us for the stresses and strains that we dare not exclude as a possibility. One cannot view with equanimity several unilateral crash programs to achieve weather control nor extended conferences at Geneva in attempts to resolve differences.

REPORT OF SPECIAL COMMISSION ON WELFARE MODIFICATION

This matter was explored in greater depth by a special commission on weather modification, authorized by the National Science Board in late 1963, which issued its report in December 1965. The relevant part of that report follows:

The program of research required to develop the capability to modify weather and climate suggest a strong emphasis upon international cooperation. The extensive and significant work that is being done in other countries underscores the need for promoting the international exchange of data and research findings for the purpose of maximizing their usefulness. The need for international collaboration in the actual planning and conduct of research activities may be expected to increase as research moves out of the laboratory and into the realm of field experiments associated with the study of the dynamics of climate, the establishment of a global weather observation network and the investigation of other aspects of the general atmospheric circulation. The technological and human resources required for the conduct of this type of research are far beyond the capability of most countries to provide individually.

Looking into the future to the time when field experiments with weather or climate modification are expanded in scope and number and involve actual at-

tempts to introduce changes in the atmosphere, some form of international collaboration will be essential in the planning and execution of projects that may have an effect not only upon the immediate localities but on areas in other countries and even upon other continents distant from the scene of work. It is possible that situations of this sort may arise in the near future if an expanded program of field experiments in cloud seeding is undertaken in areas near the northern or southern borders of the United States. An expansion in experimentation with tropical hurricanes may also present international complications.

In the present stage of world affairs, any scientific advance contributing significantly to man's ability to affect the natural environment inevitably has a bearing upon the political relations among nations and the quest for peace and security. The importance to military operations of a capability for modifying weather conditions is obvious. It must be recognized that there is a remote possibility that sometime in the future a nation might develop the capability to use weather modification to inflict damage on the economy and civil population of another country.

It is essential to develop the political and social controls over the use of this power which will maximize the opportunities for its constructive and peaceful use and minimize the factors which tend to involve it in the tensions and conflicts inherent in human society. The challenge and the opportunity which are presented to the world community by the prospect of man's achieving a power to modify his atmospheric environment is one of the most exciting long-range aspects of the subject.

Thought must be given to the types of international organizations that will be needed and the functions they should perform, if and when major operations in weather and climate modification affecting large continental areas become feasible. Whether the assignment of operational responsibility to an international agency should be considered for the future deserves thought even at this early date. Consideration might be given to new concepts of international organization and to the new problems of a technical or political nature that might be precipitated.

The very fact that the development of a capability for influencing the atmospheric environment is still in its infancy should widen the opportunity presented by this scientific endeavor to develop attitudes and patterns of collaboration which can contribute not only to the achievement of the practical, technological goals, but also to the relaxation of international tensions.

Rarely has a more ample and inviting opportunity been afforded for advance thinking and planning regarding the impact of a technological development upon international relations. Progress in the diminution of international tensions and the achievement of peace will come not so much from the dramatic resolution of basic international controversies as from the far less spectacular widening of areas of mutual interest among rival nations and from the growth in ways of cooperation. The field of weather and climate modification can serve well in this regard, in addition to realizing benefits of a more limited practical nature.

The Commission believes that:

(1) It would be highly desirable for the Government of the United States, in connection with the expansion of its program of weather and climate modification, to issue a basic statement of its views on the relationship of this national effort to the interests, hopes and possible apprehensions of the rest of the world. Early enunciation of national policy embodying two main points are recommended: (a) that it is the purpose of the United States, with normal and due regard to its own basic interests, to pursue its efforts in weather and climate modification for peaceful ends and for the constructive improvement of conditions of human life throughout the world; and (b) that the United States, recognizing the interests and concerns of other countries, welcomes and solicits their cooperation, directly and through international arrangements, for the mutual achievement of human well-being.

This cooperation should cover both research and, ultimately, operational programs of interest to other countries. It should be concerned not only with deliberate, but also inadvertent human interventions in the atmosphere that affect weather and climate. Such a policy declaration could be issued by the President or appropriately incorporated in any basic legislation on the subject of weather modification which the Congress may enact.

(2) Steps should be taken by the United States, in concert with other nations, to explore the international institutional mechanisms that may be appropriate to foster international cooperation and cope with the problems which may be

anticipated in the field of weather and climate modification. The United Nations and its specialized agencies—for example, the World Meteorological Organization—is suggested as a possible intergovernmental framework. The International Council of Scientific Unions and its associated unions—for example, the International Union of Geodesy and Geophysics—could be a suitable nongovernmental framework for these mechanisms.

(3) A major limitation affecting both advanced and developing countries is the shortage of trained personnel in atmospheric sciences at all levels. Attention should be given to the question of how greater emphasis can be given to atmospheric sciences in existing bilateral and mulitlateral programs of education and technical cooperation, and to what additional measures may be needed to fill this deficiency.

(4) Encouragement should be given to research on the impact of weather modification measures in foreign countries. The need has been previously discussed for greater attention to the biological, economic and social aspects of weather modification in the United States. A different set of problems may well be encountered in many of the developing countries where the natural environment and patterns of economic and social life present contrasts to those prevailing in this country. A greater significance of these differences must precede any attempt to evaluate the suitability of various weather and climate modification practices for specific foreign areas and to design appropriate programs of cooperation.

1965 REPORT OF COMMITTEE OF ATMOSPHERIC SCIENCES

That these views were shared by atmospheric scientists of other countries was indicated in the 1965 report of the Committee on Atmospheric Sciences established under the joint aegis of the International Union of Geodesy and Geophysics and the International Council of Scientific Unions:

A prerequisite for the scientific exploration of large-scale climate modification is the ability to assess the probable consequence of conscious intervention in natural weather processes. Global dynamic modeling techniques, to which reference has already been made, are a powerful tool with which to assess these consequences and to design scientifically meaningful experiments to be conducted in the atmosphere. At the moment, the use of mathematical models for the purpose is seriously hampered by precisely the obstacles this program is intended to remove. Any contribution to an understanding of the scientific possibilities and limitations of large-scale climate modification could be of great importance. Moreover, it is highly desirable that such studies proceed as an international cooperative effort.

VIEWS OF METEOROLOGISTS IN OTHER COUNTRIES

Meteorologists in other countries share this view. The head of the Soviet Hydrometeorological Service wrote in the World Meteorological Organization Bulletin in 1967:

It is not difficult to understand that the problem of transforming the climate on a world or regional scale is, by its very nature, an international one, requiring the united efforts and the coordination of the activities of all countries. Ever more rapidly humanity is approaching the stage in its symbiosis with nature, when it can turn to practical account all the natural resources of the Earth and when, as a result, it will become capable of thinking in terms of natural phenomena on a planetary scale . . . It is hardly necessary to prove that, in these circumstances, all mankind should regard itself as a single whole in relation to the surrounding world. There is no other way.

In a report on "The Atmospheric Sciences and Man's Needs—Priorities for the Future," published in 1971, the Committee on Atmospheric Sciences of the National Academy of Sciences recommended that "in order to safeguard the life-sustaining properties of the atmosphere for the common benefit of mankind, the U.S. Government is urged to present for adoption by the United Nations General Assembly

a resolution dedicating all weather-modification efforts to peaceful purposes and establishing, preferably within the framework of international nongovernmental scientific organizations, an advisory mechanism for consideration of weather-modification problems of potential international concern before they reach critical levels."

Particularly notable was the view of 30 scientists from 14 countries gathered in Stockholm, Sweden, during the summer of 1971 to Study Man's Impact on Climate—SMIC—under the sponsorship of the Massachusetts Institute of Technology. Their report included this passage:

> We have a conviction that mankind can influence the climate, especially if he proceeds at the present accelerating pace. We hope that the rate of progress of our understanding can match the growing urgency of taking action before some devastating forces are set in motion, forces that we may be powerless to reverse. Fortunately, the atmosphere-ocean system seems to be sufficiently ponderous and to possess enough inertia so that we probably have time to obtain a much better understanding before serious changes occur, but we must certainly devote more effort to the task than it has received in the past. Unfortunately, the machinery through which effective international action could be taken is also ponderous; in fact, in some cases we shall first have to invent such machinery, and this may take some time, too.

SMIC went on to recommend:

> That an international agreement be sought to prevent large-scale—directly affecting over 1 million square kilometers—experiments in persistent or long-term climate modification until the scientific community reaches a consensus on the consequences of the modification.

Even such a skeptic as Prof. Jerzy Neyman had a change of heart in 1970 and in the "Review of the International Statistical Institution," volume 38, No. 1, lent his name to an article which made the point:

> Having had contact with rain stimulation since 1951 (1) and after becoming thoroughly disillusioned in 1960, we changed our minds when, in 1964, we became acquainted with the seven annual reports on the Swiss hail-suppression experiment Grossversuch III (2). This excellent experiment indicated to us that, after all, there is something reasonable in the prospect of being able to stimulate rain by cloud seeding . . .

And it went on to express conviction that:

> Because of the importance of weather modification in a great number of countries, an international effort to advance the knowledge and to build up the relevant technology is clearly indicated.

STRENGTHS AND WEAKNESSES OF SENATE RESOLUTION 281

These viewpoints have been culled from the literature to drive home the point that scientists concerned with this matter have been keenly aware of its international implications for more than a decade and have been urging the kind of action which is beginning to take shape in Senate Resolution 281. This, then, brings us to our third question: What are the strengths and weaknesses of Senate Resolution 281? First, let me say, Senator Pell, that I am delighted you are exercising this initiative and I encourage you to continue with the effort to do in this area what you did so favorably in stimulating action toward a treaty concerned with the implementation of weapons of mass destruction on the ocean floor.

Since I cannot pose as an expert in international jurisprudence, it would be inappropriate to attempt editing of the proposed treaty. I

would, however, suggest that consideration be given to the following points:

1. An agreement "eschewing the hostile use of any environmental or geophysical modification" is more specific and likely to accomplish our ends than a simple prohibition of these activities as a weapon of war. It would permit clearings of supercooled fog over an Air Force base but would prohibit use of rain augmentation to harass an adversary by degrading soil trafficability or disrupting the normal hydrologic cycle.

2. I do not think military research should be explicitly prohibited because (*a*) it is almost impossible to differentiate between research directed at beneficial use and research directed at fashioning geophysical weaponry; (*b*) our national civilian effort in this field would be seriously disrupted because we freely intermingle military and civilian resources; and (*c*) our military forces must have expert scientific competence to fulfill their role in providing national security.

3. A treaty "eschewing the hostile use of environmental modification" would acquire an entirely new dimension as an imaginative application of emerging science and technology in fashioning foreign policy if it were coupled to a strong recommendation urging international cooperation along the lines suggested by the several groups, national and international, which have studied this problem over the past several years. For example, the National Academy of Sciences has pointed out a need for a strongly interdisciplinary laboratory with an explicit mission of developing the scientific and technical capability to minimize present ambiguity in attempts at weather modification. Such an institute might well be internationalized. In my view, the time is propitious to take such a step. Scientists of different nations working side by side at a research institute would be, in my judgment, an effective and desirable alternative to placing all research activities in the public domain, a step that might prove difficult in the present state of international tensions.

4. Finally, I would respectfully differ with some of my colleagues who feel that our knowledge base is inadequate to initiate the steps leading to a treaty of the kind you propose. We can see the things that have to be done to close the knowledge gaps and every fiber of my being strengthens my conviction that now, before we get any further, is the time to reach international understanding.

ADDITIONAL POINTS

In closing, I would like to make three additional points:

1. In a broad sense, the issue we are discussing today is simply one manifestation of impact on science, technology, and world affairs. Scientists are particularly sensitive that these advances be used for the betterment of mankind rather than to exacerbate conflict. Here is an opportunity to make one of those small, correct decisions that John von Neuman told us would be necessary if society is to survive technology.

2. We must stand away from the small ephemeral advantages the use of an emerging capability in weather modification might provide us in a world trouble spot and assess the long-term costs and benefits. As one who has traveled to many countries over the last few years, I am satisfied that our national interest will best be served if we adopt

as a policy a role of leadership in exploring beneficial uses of weather modification and protect ourselves against deleterious effects of inadvertent climate modification. We have a good foundation in the global atmospheric research program on which to build. It would be a tragedy if progress along these lines made during the sixties were to be irretrievably lost during the seventies.

3. If we are to adapt to the kind of world in which we are going to find ourselves during the next century, we should pay heed to the basis for rationality described by the philosopher, Emmanuel Kant, in his book "The Critique of Pure Reason," published almost 200 years ago, in which he said:

> . . . the whole interest of reason, speculative as well as practical, is centered in the three following questions: (1) What can I know? (2) What ought I to do? (3) What may I hope?

Today you are raising the question: What ought we to do? I hope that our decision will be the moral and wise one.

Thank you, Senator Case. That is the end of my testimony.

Senator CASE (presiding). Thank you very much.

DEFENSE DEPARTMENT FUNDING OF UNIVERSITY RESEARCH

Have you any comments on the question of Defense Department funding of university research in this area and have you any experience with it in your school?

Mr. MALONE. Yes, sir; it has over the years, I think, been quite helpful in adding to our fund of knowledge. The shift toward support by a civilian agency, specifically the National Science Foundation, I think is a desirable one.

Senator CASE. For what reason?

Mr. MALONE. Because there is a growing awareness that the kinds of capabilities that we have mean that we have to fashion a different kind of world, one in which the military forces are not the dominating, activating mechanism, and I think that the search for new knowledge is not always compatible with the kind of classification which is sometimes attendant on certain military programs.

Senator CASE. There is some inhibiting effect from that particular kind of relationship.

DEALING WITH COUNTRIES BEHIND IRON CURTAIN

On the other side of the coin, in your suggestion of international efforts in this research field, have you any experience, a judgment, as to the possibility of dealing, for example, with countries behind the Iron Curtain on a sound basis?

Mr. MALONE. Yes, sir, I have; and I am encouraged that it is possible to do this. We are embarked upon this now in the global atmospheric research program, and in 1974 it is planned that ships and aircraft from countries on both sides of the Iron Curtain will gather together in the Atlantic for an experiment. The attitude and the actions of the countries behind the Iron Curtain encourage me to believe that cooperation in weather research is possible.

EFFECT OF SOCIALIST SYSTEM ON SOCIALIST SCIENTISTS

Senator CASE. Does your observation include any observation of inhibiting effects of the socialist system upon the socialist scientists comparable or analagous to the military inhibitions?

Mr. MALONE. No, sir; I don't think of scientists flourishing under a socialist regime. I think that our own system is superior and that it is certainly one in which I find myself more comfortable, but I can't honestly say that there are drastic inhibitions in the pursuit of science in the socialistic regime.

CONFLICT BETWEEN SCIENTISTS' BELIEFS AND GOVERNMENT'S RELUCTANCE

Senator CASE. You are as aware, of course, as we are—more so, I am pretty sure, because of your longer experience—than I am of the conflict between the scientists who believe some kind of international agreements in this area is desirable and our official governmental reluctance to enter into it. What is the underlying reasoning, in your opinion?

Mr. MALONE. I wish I had a satisfactory answer for that. I don't.

Senator CASE. You don't have any doubt about the soundness of the scientific view.

Thank you very much. I appreciate your being here and so does Senator Pell. He has been called away because of the serious illness of his mother and asked me to carry on for him.

Mr. MALONE. Thank you.

Senator CASE. Our next witness is Dr. Richard Reed.

You have a prepared statement; haven't you?

STATEMENT OF DR. RICHARD J. REED, PRESIDENT, AMERICAN METEOROLOGICAL SOCIETY; DEPARTMENT OF ATMOSPHERIC SCIENCE, UNIVERSITY OF WASHINGTON, SEATTLE, WASH.

Mr. REED. Yes.

Senator CASE. Do you want to submit it for the record and go on your own?

Mr. REED. Yes.

Senator CASE. You could hardly do better than read it, if you want to—one page.

Mr. REED. I appreciate this opportunity, Mr. Chairman, to appear before the subcommittee and present the views of the American Meteorological Society on the issues raised by the proposed Senate Resolution 281. The statement which I am about to read was prepared by the Committee on Public Policy of the American Meteorological Society and has been approved by the executive committee as an official society statement.

The purpose of this statement is to urge that measures be taken——

Senator CASE. You agree with it, I take it?

Mr. REED. I certainly do.

Senator CASE. Did you write it?

Mr. REED. I had a hand in writing it.

The purpose of this statement is to urge that measures be taken to secure international agreement dedicating weather and climate modification to peaceful purposes. The American Meteorological Society feels that there are compelling reasons for such agreement.

Man has already demonstrated the ability to modify the weather in limited ways. Local enhancement of precipitation along mountain slopes and clearing of cold fog from airports are examples of current applications of modification techniques. Other uses, such as hail and lightning suppression, are definitely within the realm of possibility and are under active development. These are all examples of socially beneficial applications. It is also conceivable that weather and climate modification can be used for aggressive and destructive purposes.

The full potentialities of modification will not be known until much more research and field testing are accomplished. Proper testing and evaluation can only be carried out under carefully controlled conditions. Premature use of modification methods in situations where experimental controls are inadequate and where harmful consequences may ensue will jeopardize the realization of the future beneficial uses.

Weather and climate modification are specialized areas within the broader field of meteorology. Activities in these areas necessarily affect the science as a whole. Because of the global character of weather, meteorology has traditionally brought the nations of the world together in many cooperative endeavors. The operation of the national weather services, as well as the conduct of important international research efforts, such as the global atmospheric research program—GARP—depend crucially on the cooperation and good will that now exist in the international meteorological community. The present harmonious relationships could be endangered if knowledge gained in weather modification is used by one nation in a manner detrimental to another.

At present, the science and technology of weather modification are in their infancy. Their promise for good is immense; their potential as an instrument of war is not yet established. No better time could be found for dedicating man's efforts in modifying the weather to constructive use. The banning of chemical and biological warfare and of nuclear testing in the atmosphere provide ample precedents for putting limitations on man's destructive capabilities.

In order to facilitate the development of beneficial uses of weather and climate modification and to promote continued international cooperation in meteorology, the American Meteorological Society urges the U.S. Government to present for adoption by the United Nations General Assembly a resolution pledging all nations to refrain from using weather modification for hostile purposes. Thank you.

Senator CASE. Thank you very much, Dr. Reed.

POSSIBILITY OF NOT DETECTING VIOLATION OF AGREEMENT

Do you have any comments on the suggestion that was made by Dr. MacDonald that it would be possible in some area, in some of these methods of modification of the environment, to do something a million miles away that wasn't detectable; for instance, we here triggering earthquakes somewhere else? I ask you this in relation to your suggestion that the banning of chemical and biological warfare and nuclear testing in the atmosphere are precedents. Is it not true

some of these things could not be detected, as a violation of an agreement of this sort?

Mr. REED. Well, I don't think we could rule out this possibility, looking far into the future, but I think it would be very difficult to be specific on this question in our current state of knowledge. It would be hard to give you a realistic example based on what we now know.

Senator CASE. That is not a serious reason?

Mr. REED. No; we do not regard that possibility at this stage as being a serious reason.

WAS WITNESS' STATEMENT CLEARED BY NATIONAL SECURITY COUNCIL?

Senator CASE. Some evilminded person on the staff suggested I ask whether your statement was cleared by the National Security Council.

Mr. REED. I am supposedly a free agent.

Senator CASE. I am very much obliged to you, sir. Thank you. Our next witness is Mr. Werner A. Baum. Very nice to have you. Would you proceed as you would like.

STATEMENT OF WERNER A. BAUM, PRESIDENT, UNIVERSITY OF RHODE ISLAND; U.S. REPRESENTATIVE, PANEL OF EXPERTS ON METEOROLOGICAL EDUCATION AND TRAINING, U.N.

Mr. BAUM. Mr. Chairman, I deeply appreciate this opportunity to speak to Senate Resolution 281, expressing the sense of the Senate that the U.S. Government should seek the agreement of other governments to a proposed treaty prohibiting the use of any environmental or geophysical modification as a weapon of war. I appreciate the opportunity as an educator with a special concern for the welfare of future generations on this planet. I appreciate the opportunity as a meteorologist with a special concern for our understanding of the atmosphere and our ability to predict and control its behavior; and I appreciate the opportunity as a Rhode Islander.

COMMENDATION OF SENATOR PELL

As a citizen of Rhode Island, I take pride in the fact that one of our Senators had the foresight and understanding to introduce this resolution more than 4 months ago on behalf of a bipartisan group of distinguished members of the Senate. Mr. Claiborne Pell has a solidly established record of legislative effectiveness from such actions as steering through the Senate the bill establishing the sea-grant colleges and the recently enacted higher education legislation. He now adds to that record the perception of a new problem, a problem of potentially vast consequences for mankind.

MEMBERSHIP OF GROUP COLLABORATING WITH SENATOR PELL

Senator CASE. Do you recall the membership of the distinguished group you mentioned collaborating with Senator Pell?

Mr. BAUM. I have it here.

Senator CASE. Would you read the names off?

Mr. BAUM. Yes, sir.

The first name is Mr. Case; Mr. Cooper, Mr. Cranston, Mr. Hart, Mr. Hughes, Mr. Humphrey, Mr. Javits, Mr. Kennedy, Mr. McGovern, Mr. Mondale, Mr. Nelson, Mr. Tunney, and Mr. Williams.

Senator CASE. It is a bipartisan group and I appreciate your bringing that matter out.

Mr. BAUM. You are asking all of us to face that problem while there is still time.

APPROVAL OF SENATE RESOLUTION 281 WITH ONE MODIFICATION URGED

I urge you to approve Senate Resolution 281, with one major modification which I shall discuss shortly.

I urge you to do so because of my concern for those men and women who will follow us on earth. Other witnesses have discussed and will discuss the scientific status of weather modification, or weather management, as I prefer to call it, as we now see it. The plain fact is that there remains a vast sector of ignorance about the effects and natural implications of weather management. We have only one atmosphere on this planet and it may be more deadly than Russian roulette to play with it before we know what we may produce.

EXAMPLE OF ABILITY TO CREATE OR DESTROY HURRICANES

Let me give one hypothetical example, admittedly extreme, to make the basic point:

Let me suppose that we could create or destroy hurricanes at will, something we cannot now do nor expect to be able to do in the foreseeable future. Now, superficially it would seem quite desirable to eliminate hurricanes as a nuisance and a danger to mankind. However, in fact, the hurricane serves to transport large amounts of converted solar energy from tropical latitudes to polar latitudes. Somehow this transport must be accomplished if the earth is to have a reasonably stable climate, as the energy input from the sun will always be greater in the tropics than in high latitudes. If the hurricane is eliminated as one of the energy transport mechanisms, some other adjustment in the atmosphere-ocean system will have to take place. In 1972, no one can tell you what that adjustment would be. It could be a calamity for life forms as we know them. No subset of mankind should take it upon itself to initiate such a deadly gamble. Though this example is extreme, the principle it illustrates is applicable to a broad spectrum of weather management activities.

Senator CASE. Just as a layman, I would like to know a little bit more about how this transportation of energy takes place.

Mr. BAUM. Well, one significant form——

Senator CASE. Does it bring heat up from the tropics and so forth?

Mr. BAUM. Yes; and one significant way it does that, Senator, is that ocean water is evaporated by the heat in the tropics and that heat is carried northward in latent form within the water vapor. When this water vapor condenses in higher latitudes that heat is then released in the higher latitude, so you have affected a transport of heat energy from low to high latitudes that way.

Senator CASE. You have to realize many of us are children on this subject and I appreciate that very much. It is terribly helpful. But this indicates it isn't evilminded people that are going to use these

things for bad purposes; it is people playing around. When I say playing around, I mean just hit or miss, seeking of knowledge and whatnot. They may be dangerous, too?

Mr. BAUM. Quite possibly.

WORLD WEATHER PROGRAM

I urge you as a meteorologist to approve Senate Resolution 281. We have long known that better understanding of the atmosphere, as well as greater ability to predict its behavior and to manage it, would require international expenditures of money and energies on a cooperative basis on a global scale. After many years of effort, of initiative by the President of the United States, of discussion by the General Assembly of the United Nations, of supportive actions by the Congress and numerous other legislative and executive agencies around the globe, we are at last in the early stages of implementing the so-called world weather program. This program, primarily through the great improvement of our observational network and through the conduct of large-scale international field experiments, promises to increase dramatically our ability to predict weather phenomena. Success of the world weather program depends critically on faith and trust among the participating nations, nations which cover the entire spectrum of political and economic philosophies. The world weather program would and should collapse if it became clear that one or more of the participating nations was seeking knowledge for use in meteorological warfare, the rest of mankind be damned. We would lose a major opportunity for man to improve his condition on earth.

REPORT OF NATIONAL ADVISORY COMMITTEE ON OCEANS AND ATMOSPHERE

Mr. Chairman, last autumn President Nixon appointed me to the National Advisory Committee on Oceans and Atmosphere, presumably because of my background in meteorology. You will recall that this committee was established by you and your colleagues under Public Law 92–125, approved in August 1971, and was directed to submit a comprehensive annual report to the President and to the Congress setting forth an overall assessment of the status of the Nation's marine and atmospheric activities. The first report from NACOA, together with comments and recommendations by the Secretary of Commerce, will be reaching you shortly.

In its first year, the National Advisory Committee on Oceans and Atmosphere did not address itself specifically to Senate Resolution 281, so I cannot say that the committee endorses the resolution. However, we did address ourselves in depth to the status of weather modification and our report will contain a chapter on this topic. We touch on some of the same objectives to which the resolution addresses itself. Allow me to quote from an approved draft version of our report, subject to editorial change before it reaches you formally.

We note five areas in the field of weather modification in which action is required, namely, legislation, research and technology, hurricanes, public policy and international matters. In the latter area we state:

International agreement should be arrived at and the necessary institutional arrangements developed to eschew the hostile uses of weather modification and to investigate inadvertent changes in the global climate . . .

We also make the following statement in our draft report:

NACOA wishes to associate itself with the position taken by the National Academy of Sciences that in order to safeguard the life-sustaining properties of the atmosphere for the common benefit of mankind, the U.S. Government is urged to present for adoption by the United Nations General Assembly a resolution dedicating all weather modification efforts to peaceful purposes and establishing, preferably within the framework of international nongovernmental scientific organization, an advisory mechanism for consideration of weather modification problems of potential international concern before they reach critical levels.

It is clear, then, that the National Advisory Committee on Oceans and Atmosphere is supportive of the philosophy embodied in the resolution under consideration.

CONTROLLING EXPERIMENTATION BUT NOT RESEARCH SUGGESTED

Mr. Chairman, I do not propose to address myself to the details or precise working of the resolution. Others are by far more qualified to do so. In conclusion, however, I do wish to suggest one major modification. I have reference to Article I, paragraph 2, of the proposed treaty, which deals with the prohibition of research or experimentation. Experimentation, whether domestic or international, should be controlled in any case for the kinds of reasons I have already mentioned. Research, on the other hand, probably cannot and should not be controlled.

I do not see how we could effectively distinguish between weather management research which is intended for peaceful application and research which is intended for weaponry. History has surely taught us that the same research result can be used constructively or destructively. The same meteorological research is used to design civilian aircraft and the military bomber.

And, finally, while I do not want my country to use weather modification as a weapon of war, I want it to know how to do so. We cannot really control the research done by others and I want to be very certain we know at least as much or more than they know.

Thank you, Mr. Chairman.

Senator CASE. Thank you very much. I like the statement. I like the tone of it, too.

DISTINCTION BETWEEN EXPERIMENT AND RESEARCH

What is the distinction between experiment and research? I am not questioning; I want to know what you had in mind when you made this distinction.

Mr. BAUM. Research is in part clearly distinguishable, in the sense it might be theoretical; it might be laboratory; it might be the kind of research that constructs models and tests them on computers, for example.

There is a gray area which is a little difficult.

By experimentation I mean any introduction of materials into the atmosphere or any other work on the atmosphere itself where there is any reasonable doubt that there might be major consequences which cannot be anticipated. That kind of experimentation it seems to me must be very strictly controlled.

SEEDING OF HURRICANES

Senator CASE. Then you wouldn't, or would you, go into the middle of a hurricane and seed it or something like that?

Mr. BAUM. First of all, that experimentation is carefully controlled in the sense that there are very thorough ground rules and details which I don't recall offhand. The hurricane must be a certain distance away from any land mass; it must not have any reasonable probability of striking a land mass within 18 hours, or some such figure. And all those safeguards are built into those experiments.

In addition, the kind of things we are doing or are now capable of doing can produce—we are quite confident they can produce—only very minor shortlived effect.

EXPERIMENTATION ON MODERATE SCALE

Senator CASE. What you really mean is the experimentation on the moderate scale isn't going to do any substantial harm, that you are reasonably sure; you wouldn't stop the experiments such as that?

Mr. BAUM. No, I certainly would not and I doubt we can or should stop experiments that are adequately safeguarded.

WHO IS GOING TO SAFEGUARD EXPERIMENTS?

Senator CASE. Who is going to safeguard them?

Mr. BAUM. Well——

Senator CASE. Seriously.

Mr. BAUM (continuing). That is a very serious question which requires some congressional attention, in my personal opinion. We have here a problem which is somewhat analogous to the one we face in the atomic energy field, for example, as to whether the agency which is responsible for developing a field, as the AEC is, should also have safeguarding authority, as I believe it does have.

One might argue that the safeguarding authority ought to be in different hands than the agency which is trying to develop the field. At the moment I believe that, for example, in the case of hurricane modification, which is being conducted jointly by NOAA and the Navy, to the best of my knowledge it is an entirely voluntary internal self-controlled mechanism which has been established by NOAA and the Navy because of their awareness of the problem.

I believe it is entirely voluntary.

Senator CASE. Do you think that anything of the nature of an extension of the authority or the mechanisms provided in the Environmental Policy Act is desirable and should we make it more specific?

Mr. BAUM. I am not prepared to give a specific answer offhand, Senator.

I do believe that the Congress should address itself to the policy question which is contained here, and I believe that there should be a thorough exploration of alternatives and some mechanism should be established which assures the people of the United States that weather modification activity is preassessed and monitored and authorized only under circumstances which are construed to be safe and productive.

Senator CASE. Well, I appreciate that very much. The reason I brought up the analogy of the environmental policy mechanism is, first, of course, Dr. MacDonald referred to it naturally and also it is because it has no ultimate sanction except the fact that the information is brought out and laid out and everybody sees it and then the President and the Congress would have a chance to make a decision about carrying forward a certain project. This may be the best way, rather than having any policemen actually established in the legislation.

I just wondered whether that might not be a possiblity at least as a start?

I am very much obliged to you and I know Senator Pell is.

Thank you for coming.

Mr. BAUM. Thank you.

Senator CASE. Dr. Falk, nice to have you, sir.

STATEMENT OF RICHARD A. FALK, PROFESSOR OF INTERNATIONAL LAW, PRINCETON UNIVERSITY

Mr. FALK. I wish to express my gratitude to the subcommittee for allowing me to appear before it to present my views today.

With your permission, Senator Case, I will not read the entire opening statement that I prepared, but would like your permission to submit it for the record.

Senator CASE. Please do. That surely will be very much in order.

You go ahead in your own way.

Mr. FALK. Thank you.

Senator CASE. Say enough to get me started.

Mr. FALK. I will try.

U.S. TACTICS AND WEAPONRY IN INDOCHINA

In recent months I have become increasingly aware of the extent to which tactics and weaponry designed to destroy or interfere with the environment have been relied upon by the United States in Indochina. In support of this short statement, I am submitting a longer paper prepared for a June 1972, conference on environmental warfare held in Stockholm, Sweden, that considers some of these policies from the perspective of international law and offers certain proposals. (See appendix, p. 133.)

In the weeks since this paper was written, new disclosures have suggested that large-scale efforts were made in 1965–67 by the United States to cause massive forest fires in areas of South Vietnam occupied by opposition forces. Also in recent weeks evidence has been accumulating that dikes and dams have been damaged by bombardment causing a severe danger of massive flooding in the Red River Delta, imperiling the lives of millions of North Vietnamese civilians. Thus, these hearings are being held at a time when there is an international emergency of such grave proportions that even the Secretary General of the United Nations, Kurt Waldheim, has lent the prestige of his office to charges of dike-bombing and imminent catastrophe.

It is notable that Mr. Waldheim, on taking office, criticized his predecessor, U Thant, because he had at times sacrificed his influence by being critical of one or the other great powers, and it is, I would

suspect, in the belief that this is an emergency of first order of magnitude that Mr. Waldheim was led to the departure from his own injunction of prudence when he took office.

BASES FOR LEGAL APPRAISAL OF RECOURSE TO ENVIRONMENTAL WARFARE

I think it is important to make clear that although recourse to environmental warfare is often considered a relative novelty, it does not occupy a legal vacuum. We have two main bases for legal appraisal: (1) Customary principles of international law. Not all of international law is reduced to treaty form. Especially with respect to the law of war, where technology and doctrine change so rapidly, the role of customary principles of international law is especially important. These principles are set forth in greater detail in my accompanying paper, but in essence, these principles forbid reliance on tactics and weaponry that are indiscriminate in impact—that is, do not discriminate between legitimate military targets and illegitimate civilian targets; disproportional in effect—that is, that the damage caused is disproportional to the military objective served; and that are inhumane in character—that is, that are inherently cruel and offend minimum and widely shared moral sensibilities.

It should be emphasized that much of international law in all fields continues to be embodied in the form of rules and principles of customary international law.

The Supreme Court has declared in very clear terms that customary international law should be applied as often as it is relevant to a domestic legal controversy. In recent years the Supreme Court has routinely relied on customary international law to adjudicate a series of claims arising out of the expropriation of American investments by foreign governments. I think that the authoritative status of relevant principles of customary international law makes it clearly illegal to engage in most of the forms of environmental warfare that have been the subject of consideration in relation to the Indochina War.

These principles also bear, it seems to me, on the recent American contention that the bombing of the dikes or dams, to the extent it takes place, is an incidental consequence of trying to strike military targets, such as truck traffic or SAM missile implacements on dike structures in North Vietnam, represents a disproportional military objective relative to the gravity of the civilian destruction that might reasonably result from such a military policy.

The second source of existing international law that bears on this subject matter arises from the war crimes prosecutions after World War II.

We have some actual precedents which seem relevant to the assessment of the legal status of environmental warfare. These precedents were created at war crimes trials often carried out under the principal initiative of the U.S. Government.

A very significant case involves the prosecution at Nuremberg of Arthur Seyss-Inquart, a Nazi high commissioner of Holland who was charged with flooding 500,000 acres of land, thereby causing civilian misery. Seyss-Inquart was sentenced to death for various atrocious acts, but even he resisted superior orders to flood Holland indiscriminantly and proved before the court that he had thereby spared Dutch civilians much misery.

In another little reported case, the United Nations War Crimes Commission recommended that German occupying officials be charged as war criminals because they had pursued "a policy of ruthless exploitation of Polish forestry."

Two principal conclusions emerge from this analysis:

(1) Indiscriminate, disproportionate, and inhumane forms of environmental warfare violate international law as presently constituted; (2) Such a legal appraisal is evidently neither understood nor accepted by governmental officials in this country.

CONFUSION CONCERNING LEGAL STATUS OF POLICIES

It is worth noting that even journalists generally critical of these policies also appear to be confused about their legal status. Thus, Seymour Hersh implies a legal vacuum when he writes: "Technically, there are no international agreements outlawing such warfare"—New York Times, July 9, 1972, section 4, page 3—as if all of international law is treaty law; and Robert Reinhold says flatly, "Of course, fire is not new as a weapon of war; it is not illegal"—New York Times, July 23, 1972, section 4, page 2—as if past violations can serve as precedents or that the context of application is not relevant to the appraisal of a weapon's legal status.

NEED TO ADOPT EXPLICIT RULES AND PRINCIPLES OF PROHIBITION

These conclusions suggest strongly the need to adopt explicit rules and principles of prohibition with respect to all principal forms of geophysical warfare. Such a treaty of prohibition as recommended by Senate Resolution 281 is extremely important to counteract the state practice exhibited by the United States throughout the course of the Vietnam war.

It is clearly true that other governments feel entitled to rely upon war policies that were relied upon by others without formal rebuke in the past. It is also true that many intelligent members of our own society do not understand a government to be bound by international law unless the rules of prohibition are embodied in treaty form. Therefore, it seems necessary to seek general treaty rules of prohibition and then seek widespread ratification. No other course of action is likely to encourage a stable legal regime that might deter national military establishments from planning more lethal varieties of environmental warfare for future wars.

It also seems desirable to pursue a clear-cut prohibition that goes across the board. Such an approach has been successfully used in the Geneva protocol of 1925 with respect to poison gas, although recent American claims that such a prohibition does not extend to riot control agents or military herbicides threatens the clarity of the threshold.

It is very important to seek standards of prohibition that are as unambiguous as possible in international law, as enforcement and guidance depend to such a great extent upon mobilizing world public opinion and upon self-enforcement and self-interpretation on the national level. Such standards of prohibition are particularly important in this area of geophysical modification where techniques are just beginning to develop and where the drive for peaceful uses is certain

to extend the technological frontiers for weather and terrestrial manipulation in the years ahead.

For similar reasons, it is critical to retain a broad sense of the scope of geophysical warfare. It is essential to reach all human efforts to modify normal air and water flows with the intention of securing a military advantage. It is also necessary to embrace military efforts to induce earthquakes or volcanoes.

And, finally, it is necessary to include military tactics designed to alter the earth's surface, as by deforestation and defoliation, whether by Rome plow, fire, or chemical. We are dealing with an amorphous set of military possibilities that may pose dangerous threats to national security and world stability unless effectively discouraged by a strong treaty of prohibition.

The future possibility of a geophysical cold war or secret war is very menacing; the target society or region may not even know that it is being intentionally victimized by its adversary.

One purpose of such a treaty of prohibition is to help crystallize a moral consensus that reinforces the legal claims. The process of treaty ratification is itself important because it lends the prestige of governments to a specific legal undertaking and obliges national officials to justify the legal obligations in relation to national interests.

ECOCIDE OR GEOCIDE CONVENTION SUGGESTED

I would also like to emphasize that, in addition to Senate Resolution 281, it would be desirable for this committee to hold hearings in the near future to consider proposing the preparation for early adoption of an ecocide or geocide convention to complement the genocide convention. Such a proposal would help focus world attention on the magnitude of the problems posed by geophysical warfare and might strengthen inhibitions on weapons development and use in the future. I have prepared a draft ecocide convention which is submitted here as annex 1 of my supporting paper.

CONNECTION BETWEEN PRESENT CRISIS AND EFFORT TO SPARE MANKIND

I would like to conclude my statement by stressing the connection between the present crisis created by our tactics in Indochina and a genuine effort to spare mankind from geophysical warfare in the future.

To be silent about the present crimes against the environment is to compromise the integrity of the wider claims on the subject. I would appeal to you not only in your capacity as elected representatives of the American people, but also as human beings, given a small opportunity to raise your voices against the prospect of awesome calamity in Vietnam should the combined effects of artificial rainmaking, natural precipitation, and weakened and wrecked dams and dikes cause major flooding during the weeks ahead in the Red River Delta.

One eyewitness observer of the bombing of the dikes, the Swedish Ambassador to North Vietnam, Jean-Christophe Oberg, a respected diplomat, has said:

> Everyone, even diplomats, must react as human beings. I have no intention of witnessing passively what is happening.

And on another recent occasion, Ambassador Oberg observed:

If a catastrophe occurs in a few months, at the time of the monsoon, we shall know who is responsible. But this must not be allowed to happen. The lives of millions of people are in jeopardy and an unprecedented famine could occur in North Vietnam.

Thank you.

(Mr. Falk's prepared statement follows:)

PREPARED STATEMENT OF RICHARD A. FALK, PROFESSOR OF INTERNATIONAL LAW, PRINCETON UNIVERSITY, HEARINGS, JULY 27, 1972, SUBCOMMITTEE ON OCEANS AND INTERNATIONAL ENVIRONMENT OF U.S. SENATE COMMITTEE ON FOREIGN RELATIONS

By way of background, the subject of these hearings joins two of my deepest professional concerns. As an international lawyer and political scientist, I have been interested in the global dimensions of environmental problems and have published a book entitled *This Endangered Planet: Prospects and Proposals for Human Survival* (Random House, 1971). For more than a decade I have been professionally concerned and personally disturbed by America's involvement in the Indochina War and have devoted considerable attention to the legal aspects of this involvement. In this connection I have served as Chairman and Rapporteur of the Civil War Panel of the American Society of International Law, Chairman of the Consultative Council of the Lawyers Committee on American Policy Towards Vietnam, and editor of and contributor to a three volume series entitled *The Vietnam War and International Law* (Princeton University Press, 1968, 1969, 1972).

In recent months I have become increasingly aware of the extent to which tactics and weaponry designed to destroy or interfere with the environment have been relied upon by the United States in Indochina. In support of this short statement, I am submitting a longer paper prepared for a June 1972 conference on environmental warfare held in Stockholm, Sweden, that considers some of these policies from the perspective of international law and offers certain proposals. In the weeks since this paper was written new disclosures have suggested that large-scale efforts were made in 1965–67 by the United States to cause massive forest fires in areas of South Vietnam occupied by opposition forces. Also in recent weeks evidence has been accumulating that dikes and dams have been damaged by bombardment causing a severe danger of massive flooding in the Red River Delta imperiling the lives of millions of North Vietnamese civilians. Thus these hearings are being held at a time when there is an international emergency of such grave proportions that even the Secretary General of the United Nations, Kurt Waldheim, has lent the prestige of his office to charges of dike-bombing and imminent catastrophe.

I think it important to make clear that although recourse to environmental warfare is often considered a relative novelty it does not occupy a legal vacuum. We have two main bases for legal appraisal:

(*1*) *Customary principles of international law.*—Not all of international law is reduced to treaty form. Especially with respect to the law of war, where technology and doctrine change so rapidly, the roll of customary principles of international law is especially important. These principles are set forth in greater detail in my accompanying paper, but in essence, these principles forbid reliance on tactics and weaponry that are *indiscriminate* in impact (that is, do not discriminate between legitimate military targets and illegitimate civilian targets), *disproportional* in effect (that is, that the damage caused is disproportional to the military objective served), and that are *inhumane* in character (that is, that are inherently cruel and offend minimum and widely shared moral sensibilities). It should be emphasized that much of international law in all fields continues to be embodied in the form of rules and principles of customary international law. The Supreme Court has declared in very clear terms that customary international law should be applied as often as it is relevant to a domestic legal controversy. In recent years the Supreme Court has routinely relied on customary international law to adjudicate a series of claims arising out of the expropriation of American investments by foreign governments. I think that the authoritative status of relevant principles of customary international law makes it clearly illegal to engage in most of the forms of environmental warfare that have been the subject of consideration in relation to the Indochina War.

(2) *War Crimes Prosecutions after World War II.*—We have some actual precedents which seem relevant to the assessment of the legal status of environmental warfare. These precedents were created at war crimes trials often carried out under the principal initiative of the United States Government. A very significant case involves the prosecution at Nuremberg of Arthur Seyss-Inquart, a Nazi High Commissioner of Holland who was charged, among other things, with flooding 500,000 acres of land, thereby causing civilian misery. Seyss-Inquart was sentenced to death for various atrocious acts, but even he resisted superior orders to flood Holland indiscriminately and proved before the court that he had thereby spared Dutch civilians much misery. In another little reported case, the United Nations War Crimes Commission recommended that German occupying officials be charged as war criminals because they had pursued "a policy of ruthless exploitation of Polish forestry." War crimes are defined in Nuremberg Principle VI (b) as including "plunder of public or private property, wanton destruction of cities, towns, or villages, or devastation not justified by military necessity." This language is broad enough to reach the main forms of environmental warfare.

It is important also to appreciate that even American recourse to environmental tactics and policies is not a novelty. In the Korean War on May 13, 1953, twenty F–84 fighter-bombers attacked the Toksan irrigation dam in North Korea and, according to a staff study published in the Air University Quarterly Review "skip-bombed their loads of high explosives into the hard-packed earthen walls of the dam." In praising the efficacy of these strikes the staff study considered their main impact to have been on 75% of "the controlled water supply for North Korea's rice production." (See "Attack on the Irrigation Dams in North Korea," Air University Quarterly Review, Winter 1953–54). The study goes on to claim that the capacity of airpower to generate "rice famine" also served as a warning to future enemies of the United States. As is well-known by now, similar tactics of warfare have been repeatedly introduced into the Vietnam War. As long ago as 1965–67, the earlier period of heavy bombardment of North Vietnam, there were documented accounts of bombs falling repeatedly on dike sections. Recent disclosures, eye-witness reports, substantiated rumors, and semi-denials in relation to the bombardment of dikes and dams, artificial rainmaking, and induced forest fires lend additional substance to the generalized conclusion that waging environmental warfare, despite its dubious legal status, is unfortunately not alien to the military mind or its civilian overseers in this country.

Two principal conclusions emerge from this analysis:

(1) Indiscriminate, disproportionate, and inhumane forms of environmental warfare violate international law as presently constituted;

(2) Such a legal appraisal is evidently neither understood nor accepted by governmental officials and others in this country. It is worth noting that even journalists generally critical of these military policies also appear to be confused about their legal status. Thus, Seymour Hersch implies a legal vacuum when he writes "Technically, there are no international agreements outlawing such warfare," (*N.Y. Times*, July 9, 1972, Sect. 4, p. 3) fallaciously writing as if all of international law is treaty law; and Robert Reinhold says flatly, "Of course, fire is not new as a weapon of war; it is not illegal" (*N.Y. Times*, July 23, 1972, Sect. 4, p. 2) as if past violations can serve as precedents or that the context of use (i.e. target, purpose, etc.) is not relevant to the appraisal of a weapon's legal status.

These conclusions suggest strongly the need to adopt explicit rules and principles of prohibition with respect to all principal forms of geophysical warfare. Such a treaty of prohibition as recommended by S. Res. 281 is extremely important to counteract the state practice exhibited by the United States throughout the course of the Vietnam War. It is clearly true that other governments feel entitled to rely upon war policies that were relied upon by others without formal rebuke in the past. It is also true that many intelligent members of our own society do not understand a government to be bound by international law unless the rules of prohibition are embodied in treaty form. Therefore, it seems necessary and desirable to seek general treaty rules of prohibition and then seek widespread ratification. *Indeed, no other course of action is likely to encourage a stable legal regime that might deter national military establishments from planning more lethal varieties of environmental warfare for future wars.*

It also seems essential to insist upon a clear-cut prohibition that goes across the board. Such an approach has been successfully used in the Geneva Protocol of 1925 with respect to poison gas, although recent American claims that such a prohibition does not extend to riot control agents or military herbicides threatens

to compromise the clarity of the threshold. It is very important to seek standards of prohibition that are as unambiguous as possible in international law, as enforcement and policy guidance depend to such a great extent upon mobilizing world public opinion and upon self-enforcement and self-interpretation on the national level. Such standards of prohibition are particularly important in this area of geophysical modification where techniques are just beginning to develop and where the drive for "peaceful uses" is certain to extend the technological frontiers for weather and terrestrial manipulation in the years ahead far beyond the horizons of present anticipation.

For similar reasons, it is critical to retain a broad sense of the scope of geophysical warfare. It is essential to reach all human efforts to modify normal air and water flows with the intention of securing a military advantage. It is also necessary to embrace military efforts to induce earthquakes or volcanos. And, finally, it is necessary to include military tactics designed to alter the earth's surface, as by deforestation and defoliation, whether by Rome Plow, fire or chemical, or as by flooding, whether by rain making or the bombardment of dikes, dams, and irrigation systems. We are dealing with an indefinite, but menacing, set of military possibilities that may pose dangerous threats to national security and world stability unless effectively discouraged by a strong treaty of prohibition. The future possibility of a geophysical "cold war" or "secret war" is particularly troublesome; the target society or region may not even know that it is being intentionally victimized by its adversary, or it may suspect that it is a target when adverse natural phenomena are indeed accidents of nature.

One purpose of such a treaty of prohibition is to help crystallize a moral consensus that reinforces the legal claims. The process of treaty ratification is itself helpful because it lends the prestige and honor of governments to a specific legal undertaking and obliges national officials to justify the legal obligations in relation to national interests.

I would hope that this Subcommittee would also hold hearings in the near future to consider the wisdom of proposing the adopton of an ecocide or geocide convention to compliment the Genocide Convention. Such a proposal would help focus world attention on the magnitude of the problems posed by geophysical warfare and might strengthen inhibitions on weapons developments and use in the future. I have prepared a draft ecocide convention which is submitted here as Annex 1 of my supporting paper.

I would like to conclude my statement by stressing the connection between the present crisis created by our tactics in Indochina and a genuine effort to spare mankind from geophysical warfare in the future. To be silent about the present crimes against the environment is to compromise the integrity of wider claims on this initial subject. I would appeal to you not only in your capacity as elected representatives of the American people, but as human beings, given a small opportunity to raise your voices against the prospect of awesome calamity in Vietnam should the combined effects of artificial rainmaking, natural precipitation, and weakened and wrecked dams and dikes cause major flooding during the weeks ahead in the Red River Delta. One eyewitness observer of the bombing of the dikes, the Swedish Ambassador to North Vietnam, Jean-Christophe Oberg, a respected diplomat, has said, "Everyone, even diplomats, must react as human beings . . . I have no intention of witnessing passively what is happening." And on another recent occasion Ambassador Oberg observed: "If a catastrophe occurs in a few months, at the time of the monsoon, we shall know who is responsible. But this must not be allowed to happen. The lives of millions of people are in jeopardy, and an unprecedented famine could occur in North Vietnam." (from Fred Branfman's collection of eye-witness Western reports of bombing of dikes.)

Senator CASE. Thank you, Dr. Falk.

Your longer paper will be included in the record and the annexes to it that you referred to. (See appendix, p.133.)

I find nothing to question in your statement and I am very grateful to you for coming. I know Senator Pell will be, too.

Thank you very much.

Mr. FALK. Thank you.

Senator CASE. Is there anything that anyone else here would like to comment on as to what has been said so far by any of the witnesses?

ISSUE OF PROHIBITION OF RESEARCH

Mr. FALK. Could I make a brief comment on the issue of the prohibition of research?

Senator CASE. I wish you would.

Mr. FALK. I unfortunately didn't have the benefit of the resolution before I came today because I was in upstate Vermont, but it seems to me that it is important to balance on the one side the sorts of considerations that have been advanced for not inhibiting research with the dangers that seem to me so self-evident in many areas of government of allowing research of this character to proceed under classified or secret auspices. So I would think that one way of modifying the present language of the resolution and still not losing all its important inhibiting effect would be to require research to be conducted on an open or unclassified basis and be subjected to some form of congressional and possible citizen scrutiny on a continuing basis.

I think that, as I say, there is so much evidence that governments and our own Government has abused the prerogatives of secrecy with respect to subject matter of this sort that I think it is very important not to altogether eliminate the effort to control research that was placed in the original treaty formulation.

Senator CASE. I am very much obliged for that particular insight, too. It is somewhat along the line of the idea of the environmental quality openness without necessarily a specific policeman to say no.

I take it you rely upon the scientific community and the public and the Congress in the light of knowledge of what was proposed or is going to be, to apply the restraint at least in the first instance?

Mr. FALK. Yes, sir; that is correct, and also not to allow any exclusive military research. There could be research with military participation, it seems to me, but not research that was under the exclusive domain of the military or other security-related agencies of the Government. All research should involve participation of civilian components, in other words, and all research, it seems to me, should be subject to public scrutiny with possibly certain very exceptional circumstances justifying some kind of limited nondisclosure.

I can imagine certain things which it would be better for the world not to know and, therefore, I can see certain exceptions, circumstances where it might accordingly be appropriate to overcome this general bias in favor of openness.

Senator CASE. We already have a lot of controlled research and secret research under the Atomic Energy Act, of course. We have been going the other way in this area as far as legislation goes. I think this is a very interesting and provocative suggestion and I apreciate it.

Mr. FALK. Thank you.

Senator CASE. Thank you very much.

The hearing will be adjourned, subject to the call of the Chair.

(Whereupon, at 12:25 p.m., the subcommittee adjourned, subject to the call of the Chair.)

APPENDIX

MEMBERS OF CONGRESS FOR PEACE THROUGH LAW,
Washington, D.C., June 15, 1971.

Hon. MELVIN R. LAIRD,
Secretary of Defense,
Washington, D.C.

DEAR MR. SECRETARY: We have noted recent reports that the Air Force is using weather modification techniques to wash out sections of the Ho Chi Minh Trail. At first glance, this appears to be a relatively harmless defensive project, but it carries some disturbing implications.

Using weather modification as a military tool opens the door to a vast unknown category of warfare. Although techniques are primitive today, experience with other military systems suggests that refinements inevitably will come.

At present, we do not know the ecological consequences of such activities. The possible redirection of storm centers producing prolonged drought conditions or fostering other types of climatic changes, however, suggests awesome potential. To move into this area without the most painstaking analysis of environmental implications would be most unwise. Indeed, it would be scientifically and morally wrong for the United States to become the first nation to use such capability for military purposes.

Unless there is a clear government policy to the contrary, the United States may find itself charged, rightly or wrongly, with initiating a new form of warfare. Other nations might well justify wartime weather or climatic alteration activity on the basis of our involvement in this area. U.S. military weather modification projects could also embarrass our scientists engaged in legitimate research.

We feel the Administration should discontinue any weather modification operation in a military environment. We would appreciate being advised of the administration's policy on this question as well as obtaining the complete background about Air Force weather alteration activities in Indo-China and any other similar projects planned or underway.

Sincerely,

GILBERT GUDE,
Chairman, Committee on World Environment and International Cooperation.
ALAN CRANSTON,
Vice-Chairman, Committee on World Environment and International Cooperation.

OFFICE OF THE SECRETARY OF DEFENSE,
Washington, D.C., June 22, 1971.

Hon. ALAN CRANSTON,
Vice-chairman, Committee on World Environment and International Co-operation, Members of Congress for Peace through Law, Washington, D.C.

DEAR SENATOR CRANSTON: Secretary Laird has asked that I acknowledge your letter of June 15 regarding weather modification techniques.

Your letter is receiving attention and you will be advised further at a later date.

Sincerely,

J. F. LAWRENCE,
Brigadier General, USMC,
Deputy Assistant to the Secretary for Legislative Affairs.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., July 12, 1971.

Hon. GILBERT GUDE,
Chairman, Committee on World Environment and International Co-operation, Members of Congress for Peace through Law, Washington, D.C.

DEAR MR. GUDE: Your letter of June 15, 1971, which was addressed to the Secretary of Defense, has been referred to this office for reply. In your letter you expressed concern over reported military use of weather modification techniques by the Department of Defense.

The possibilities inherent in weather modification techniques to support military operations have been the subject of discussion for more than 20 years. For a number of these years the Department of Defense has been conducting several modest research and development programs relating to various forms of weather modification. These programs are carried out, in concert with other Government Departments and Agencies, under the aegis of the Interdepartmental Committee for Atmospheric Sciences (ICAS). The results of the programs are reported annually to ICAS, and are additionally reported in appropriate scientific journals for consideration by the scientific community.

Weather modification research on the part of the Department of Defense stems principally from two major interests. The first of these is the enhancement of our own operational posture through weather modification activities. Two examples of this type of employment are: The suppression of hail and lightning (to reduce damage to military property and equipment, and to increase safety of operations), and the dissipation of fog at airfields and within harbors (to enhance operational safety of aircraft and ships). The other interest is an understanding of what capabilities our potential enemies may possess in the area of weather modification operations. For example, the Soviets have demonstrated a technique for hail suppression. Suitably designed artillery shells are fired into cumulus clouds to reduce hailfall from those clouds. These experiments are conducted by Soviet military personnel using military equipment.

DOD research in this area is conducted in the laboratory and in the field. The field efforts, usually joint ventures with one or more other government agencies, are all carefully controlled operations, based on the best available theoretical knowledge. One example of fruitful field research has been the investigation of precipitation augmentation. This research has established a significant point: There is no known way to "make rain" under all conditions. When the proper meteorological conditions prevail (that is, when clouds capable of producing natural rain exist), it is a relatively simple matter to increase the amount of rain which will fall. The amount of increase is frequently of the order of 30 to 50%. This augmentation is well within the natural limits of rainfall for regions within which experiments have been conducted. Massive downpours, far in excess of natural occurrences, have not been produced, and theoretical knowledge at hand indicates that this will probably always be the case. Similarly, there is no known technique which will permit the steering of storms into a specific area. The closest approach to large storm modification thus far attempted is the Department of Commerce (NOAA)/Department of Defense joint effort known as Project STORMFURY. In this project, studies are being made on ways to ameliorate the maximum wind speed in hurricanes and typhoons in order to reduce the severity of damage caused by these very destructive storms.

The field capabilities of the Department of Defense have been utilized on several occasions in attempts to alleviate severe drought conditions. In 1969 at the request of the Government of the Philippines, the Department of Defense conducted a six months' precipitation augmentation project in the Philippine archipelago. The Philippine Government considered the undertaking so successful that they have subsequently taken steps to acquire an independent capability to augment rainfall on an annual basis when required. Similarly, we have just completed a one-month project in Texas at the request of the Governor of that State. The operation appears to have been moderately successful in alleviating Texas' severe water shortage. On the other hand, attempts to solve similar problems in India and at Midway Islands were near or total failures due to the absence of suitable cloud formations.

Laboratory efforts conducted by the Department of Defense are designed in large part to explore the questions concerning the ecology that you raise in your letter. Many of these experiments are numerical investigations which utilize large computers to model the atmosphere. Because of the magnitude of the problem, this effort is currently very much limited by the size and capabilities of existing

computers. When new computers now being designed are placed in service, however, we hope this effort can be expanded to include models on a global scale. Such work is being undertaken because DOD recognizes, as does your Committee, that large scale weather modification operations must not be attempted until there is full and reliable theoretical knowledge which assures that such operations will not have an adverse effect upon the World's climate.

Regarding your question of the Administration's policy toward weather modification, the Under Secretaries' Committee, at the request of Dr. Kissinger, is currently meeting to formulate a definitive National Policy. Presumably this policy, when completed, will be announced to the Nation in some appropriate fashion.

The Department of Defense has no comment concerning the reported use of weather modification techniques in Indo-China.

Sincerely,

JOHN S. FOSTER, JR.

MEMBERS OF CONGRESS FOR PEACE THROUGH LAW,
Washington, D.C., October 15, 1971.

Hon. MELVIN R. LAIRD,
Secretary of Defense,
Washington, D.C.

DEAR MR. SECRETARY: In a letter dated June 15, we wrote requesting specific information regarding the use of weather modification techniques by the Air Force or other U.S. agencies in South East Asia.

Dr. John S. Foster, in his reply July 12, gave us useful data concerning the development for such techniques, but failed to direct his comments specifically to our request. We find his decision to withhold information with a "no comment" unsatisfactory and inappropriate.

In particular, we would like answers to the following questions:

What types of weather alteration programs are conducted in South East Asia? Under whose authority? In which countries? Do these countries have knowledge of and give approval for these activities? How long have these programs been in force, operationally and experimentally?

How many people are involved and what are the total yearly costs associated with these activities?

What is the national policy regarding the use of weather modification in a war zone or as a military tactic? Who established this policy and how is it reviewed for specific projects?

As you know, there has been increasing concern among our colleagues about excessive classification of information—a concern which we share particularly in relation to a policy as potentially dangerous and counterproductive as weather alteration. Since we assume that the information requested would not be of such a sensitive nature as to warrant the invoking of Executive privilege by the President, we do expect a complete reply.

We remain deeply concerned about the disturbing implications of these activities and would be pleased to cooperate with the Administration in developing national policy in this area.

Sincerely,

GILBERT GUDE,
Chairman, Committee on World Environment and International Cooperation.
ALAN CRANSTON,
Vice-Chairman, Committee on World Environment and International Cooperation.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., December 8, 1971.

Hon. GILBERT GUDE,
Chairman, Committee on World Environment and International Cooperation.
Hon. ALAN CRANSTON,
Vice-Chairman, Committee on World Environment and International Cooperation, Members of Congress for Peace through Law, Washington, D.C.

GENTLEMEN: This is in response to your letter of 15 October 1971 to the Secretary of Defense, wherein you express dissatisfaction with my earlier answer to your inquiry regarding our activities in the field of weather modification.

Certain aspects of our work in this area are classified. Recognizing that the Congress is concerned with activities which bear on the quality of our environment I have, at the direction of Secretary Laird, seen to it that the Chairmen of the Committees of Congress with primary responsibility for this Department's operations have been completely informed regarding the details of all classified weather modification undertakings by the Department. However, since the information to which I refer has a definite relationship to national security and is classified as a result, I find it necessary to respectfully and regretfully decline to make a public disclosure of the details of these activities at this time.

Sincerely,

JOHN S. FOSTER, JR.

MEMBERS OF CONGRESS FOR PEACE THROUGH LAW,
Washington, D.C., January 27, 1972.

THE PRESIDENT,
The White House,
Washington, D.C.

DEAR MR. PRESIDENT: We are concerned that the United States is experimenting with weather modification as a military tactic in South East Asia. It is our belief that this program is extremely volatile and bears with it the possibility of considerable embarrassment.

Using weather modification as a military tool opens the door to a vast unknown category of warfare. At present, we simply do not know the potential ecological consequences of such activities. Although techniques are primitive today, experience with other military systems suggests that refinements inevitably will come.

We recognize that civilian research in the weather modification field has great merit. The world's food problem remains critical and we must learn to manage our environment productively, yet without harm. That is no justification, however, for the *unilateral* military use of this technology. Furthermore, to continue the bulk of weather research under military auspices is an unwarranted intrusion into the scientific community. If other nations sought to make an issue of our actions, it could prove highly embarrassing to our own scientists.

The use of military weather modification reminds us of the early use of defoliants and herbicides in Vietnam. Then, as now, we had little knowledge of the long-range environmental or political implications. There seemed to be no clear cut national policy and as a result the U.S. was severely criticized.

We hope that you will see fit to review the present activities in Indochina and establish an announced policy prohibiting the future use of environmental warfare. We would be pleased to cooperate with you in this matter and offer any assistance that you might deem appropriate.

Sincerely yours,

GILBERT GUDE,
Member of Congress,
Chairman.

ALAN CRANSTON,
U.S. Senator,
Vice-Chairman.

THE WHITE HOUSE,
Washington, February 1, 1972.

HON. GILBERT GUDE,
House of Representatives,
Washington, D.C.

DEAR GIL: This will acknowledge your letter of January 27 in which you were joined by Senator Cranston, on behalf of the Members of Congress for Peace through Law, in urging that weather modification techniques not be used as a military tool in Southeast Asia. You may be assured your letter will be brought to the President's attention and also shared with the appropriate members of the staff.

With cordial regards,

Sincerely,

WILLIAM E. TIMMONS,
Assistant to the President.

THE SECRETARY OF DEFENSE,
Washington, March 18, 1972.

Hon. GILBERT GUDE,
House of Representatives,
Washington, D.C.

DEAR MR. GUDE: Your letter of 27 January 1972, signed by you and Senator Cranston, addressed to the President, has been referred to me for reply. In your letter you expressed concern with the possible military use of weather modification.

The Departments of Commerce and Interior together with the National Science Foundation have the major portion of the national weather modification programs. The Department of Defense has no unique weather modification techniques nor is its program of research large in comparison to the total Federal effort.

Some aspects of our work in this area have a definite relationship to national security and are classified accordingly. The Chairmen of the Senate and House Appropriations and Armed Services Committees have been fully informed on these classified aspects.

Sincerely,

(Signed) MELVIN R. LAIRD.

MEMBERS OF CONGRESS FOR PEACE THROUGH LAW,
Washington, D.C., March 31, 1972.

THE PRESIDENT,
The White House,
Washington, D.C.

DEAR MR. PRESIDENT: Since last June I have corresponded with various officials of your Administration regarding military applications of weather modification. Secretary Laird has informed me, however, that this subject is classified due to its sensitive national security implications.

With science progressing at a geometric rate, it will not be long before the capability to alter weather or even specific climates is an accepted fact. Long before then we must consider the environmental and political as well as military consequences of this new technology. It will be far easier to deal with this problem now rather than later.

I would hope that you could review the weather modification program to determine if it can be declassified. If U.S. projects are exclusively defensive in nature, then that should be made known. If not, there is serious question about the propriety of this activity.

More important, however, I would recommend that the Department of Defense issue a "no first use" proclamation regarding the offensive employment of environmental warfare. Perhaps this could be incorporated into a carefully prepared international treaty initiated by this Administration.

Your leadership in the field of chemical-biological warfare offers the best possible model for this proposed treaty. Both CBW and weather modification have serious command and control problems and if used, would be indiscriminate.

It would seem logical that the issue of weather modification should be brought before the Conference of the Committee on Disarmament in Geneva. This step would again demonstrate the willingness of the U.S. to take leadership on arms control questions.

Sincerely,

GILBERT GUDE,
Chairman, World Environment and
International Cooperation Committee.

THE WHITE HOUSE,
Washington, April 4, 1972.

Hon. GILBERT GUDE,
House of Representatives,
Washington, D.C.

DEAR GIL: In Bill Timmons' absence, I wish to acknowledge and thank you for your letter on behalf of Members of Congress for Peace through Law suggesting that the subject of the military application of weather modification be placed on the agenda for discussion at the Conference of the Committee on Disarmament at Geneva.

You may be assured your letter will be brought to the President's attention and also shared with the appropriate members of the staff.

With warm regards,

Sincerely,

RICHARD K. COOK,
Deputy Assistant to the President.

[From Science magazine, Vol. 176, June 16, 1972]

RAINMAKING: RUMORED USE OVER LAOS ALARMS ARMS EXPERTS, SCIENTISTS

(By Deborah Shapley)

For the past year, rumors and speculation, along with occasional bits of circumstantial evidence, have accumulated in Washington to the effect that the military has tried to increase rainfall in Indochina to hinder enemy infiltration into South Vietnam—in effect, using the weather as a weapon of war. But Pentagon officials have been extremely tight-lipped about it, even to prominent members of Congress, and it appears that the old saying is now turned around: The generals are probably doing something about the weather, but nobody's talking about it. *The Pentagon Papers* makes references to such activities as having been successfully carried out in Laos, and a Jack Anderson column in the Washington *Post* a year ago described a top-secret operation over the Ho Chi Minh trail.

The only denial so far has come from Department of Defense (DOD) Secretary Melvin R. Laird in congressional testimony. However, all Laird denied was the use of weather control "over North Vietnam," and, since the Anderson column and *The Pentagon Papers* concern Laos and the Ho Chi Minh trail, which runs through Laos and Cambodia, no real answers to the speculations have been provided.

The DOD has admitted that various forms of climate modification have been considered by the military for more than 20 years. A well-known geophysicist formerly with DOD's Institute for Defense Analyses, Gordon J. F. MacDonald (who now sits on the Council for Environmental Quality), wrote a Cassandra-like chapter on potential geophysical warfare in 1968, which described control of rainfall, drought, earthquakes, and even possible tinkering in the Arctic.[1] The Indochina allegations are limited to charges that the DOD has augmented rainfall to muddy up trails, thus hindering the flow of men and vehicles to the south, but some scientists and arms experts regard even this limited activity as a camel's nose under the geophysical tent.

The issue has an important scientific dimension, too, for meteorology is one of the most internationally minded of all scientific fields. Many prominent U.S. meteorologists have for years favored a ban on military uses of weather control. Describing their reactions even to the possibility that these techniques have been used, they use such words as "distressed," and "appalled." They add that weather control in Indochina could hurt international, peaceful weather research. Hence, the issue of whether the DOD has been, or might be, seeding clouds over Asia holds implications beyond the horizons of Indochina alone.

The only direct evidence that weather modification techniques have been used in Indochina comes from some references in *The Pentagon Papers* which indicate that the Joint Chiefs of Staff (JCS), probably in 1966, had rainfall experiments conducted over Laos "successfully." In 1967, the JCS urged President Lyndon B. Johnson to authorize an operational weather program with the innocuous name of Operation POP EYE as a means of escalating the war. According to the Gravel edition of the papers, volume 4, page 421, the JCS suggested to Johnson in a memo that this might be one way of widening the war with minimal political repercussions at home.[2]

4. LAOS OPERATIONS—Continue as at present plus Operation POP EYE to reduce trafficability along infiltration routes.

Authority/Policy Changes—Authorization required to implement operational phase of weather modification process previously successfully tested and evaluated in same area.

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[1] G. J. F. MacDonald, "How to wreck the environment," in *Unless Peace Comes: A Scientific Forecast of New Weapons*, Nigel Calder, Ed. (Viking Press, New York, 1968).

[2] *The Pentagon Papers: The Defense Department History of United States Decisionmaking on Vietnam* (Beacon Press, Boston, Mass.), vol. 4.

Risks/Impact—Normal military operational risks. Risk of compromise is minimal.

Again, on 21 February 1967, the President was handed a "shopping list" of escalation proposals recommended by the JCS and apparently written by John McNaughton of the Office of International Security Affairs in DOD. Volume 4, page 146, lists among the recommendations:

8. Cause interdicting rains in or near Laos.

The narrative text summarizes the rest of the memo:

The discussion section of the paper dealt with each of the eight specific option areas noting our capability in each instance to inflict heavy damage or complete destruction to the facilities in question.

Evidently, the JCS considered weather modification worthy of consideration as one way of waging war.

Some who have been closely associated with *The Pentagon Papers* study, asked about these references, pointed out that the study was compiled by civilians with relatively little knowledge or data on day-to-day combat operations. They say it is reasonable to infer that the relatively few references to weather modification activities in *The Pentagon Papers* are no clue to the actual extent of military weather modification operations.

The other evidence that rainfall augmentation might still be going on is circumstantial. On 18 March 1971, the well-known syndicated columnist, Jack Anderson, in his column in the Washington *Post*, claimed that the Ho Chi Minh trail, which runs through both Laos and Cambodia, had been seeded by the Air Force since 1967 (the date of JCS recommendations listed in *The Pentagon Papers*). In part, Anderson wrote:

The hush-hush project, known by the code name "Intermediary-Compatriot," was started in 1967 to hamper enemy logistics. Those who fly the rainmaking missions believe they have increased the precipitation over the jungle roadways during the wet seasons.

. . . These assertedly have caused flooding conditions along the trails, making them impassable.

The Ho Chi Minh trails will get their next monsoon bath from May to September. . . . Only those with top security clearance knew, until now, that nature would be assisted by the U.S. Air Force.

Anderson was alleging that "Intermediary-Compatriot" would be going on from May to September 1971. The Pentagon has never confirmed or denied the charge. Its response, in fact, has been to say that the answers are classified—a statement that leads some liberal congressmen to conclude they must be doing it. John S. Foster, Director of Defense Research and Engineering (DR & E), replied in an almost identical fashion to written queries from Senator Claiborne Pell (D-R.I.), Senator Alan Cranston (D-Calif.), and Representative Gilbert Gude (R-Md.).

Certain aspects of our work in this area [weather modification] are classified. Recognizing that the Congress is concerned . . . I have, at the direction of Secretary Laird seen to it that the Chairmen of the Committees of Congress with primary responsibility for this Department's operations have been completely informed regarding the details of all classified weather modification undertakings by the Department. However, since the information to which I refer has a definite relationship to national security and is classified as a result, I find it necessary to respectfully and regretfully decline to make a public disclosure of the details of these activities at this time.

Pell will try to get some elaboration on this statement from DOD when he holds hearings on a draft treaty banning environmental modifications for military purposes. However, so far, Laird is the only DOD official who has been asked point-blank whether the military is modifying weather in the war. In April, Senator J. William Fulbright (D-Ark.), asked him about it, although the questioning was limited to North Vietnam.

FULBRIGHT: ". . . In other words, you have never engaged in the use of this, whatever it may be, weather control, although you have a capability of it. Is that the reason?"

LAIRD: "We have never engaged in that type of activity over North Vietnam."

Although it sounds harmless, in Indochina, rainfall augmentation can have key military and tactical advantages. The purpose of cloud seeding would be to muddy up the hundreds of trail networks which wind southward and eastward through Laos and Cambodia, providing vital links between North Vietnam and China, and South Vietnam. Impeding the traffic of men and materiel which

flows constantly through this jungled, often mountainous terrain has been the key objective of the United States' billion-dollar bombing campaigns since 1965.

But a flood can mess up a road or pathway as much as a bomb explosion can. Moreover, it is much cheaper, and highly covert. Scientists say that only if the Laotians and Cambodians took extensive samples of rainwater and systematically tested them for trace elements, could they actually prove that the normal rainfall had been artificially increased.

Moreover, this form of weather modification is equally covert to the side employing it. According to civilian scientists, a cloud-seeding plane can be any type of plane. It needs little special equipment, and 35 to 100 pounds of silver iodide for a 6-hour seeding mission. Even if equipped with racks for the dropping of pyrotechnic flares—one technique for seeding—a weather modification plane would look the same as a reconnaissance plane which drops similar flares. Not only would the Laotians have a difficult time discovering our cloud-seeding activities, Americans would have difficulty too.[3]

One of the most eminent of DOD's weather scientists is Pierre Saint-Amand, who is head of the Earth and Planetary Sciences Division of the Naval Ordnance Laboratory, Naval Weapons Center, China Lake, California. He says that the alleged use of cloud seeding in Indochina is "outside of my ability to answer." Like other DOD spokesmen on the subject of weather modification, Saint-Amand is eager to point out that the Soviet Union is doing extensive weather modification research.

As to the potential of cloud seeding for impeding infiltration routes, Saint-Amand said, "I don't think using weather to discourage people from moving is a bad thing to do. If you estimate the amount of damage done by impeding someone's transportation, versus blowing them up or burning them up, I don't think it is so immoral." In effect weather is no less humane a weapon than bombing and gunfire.

Civilian meteorologists, however, tend to be far more cautious about the efficacy of current weather modification techniques. They say, anxiously, that in few cases can cloud seeding be actually proved to work, The DOD, for example, claims that a cloud-seeding project over Texas during a drought was successful because heavy rainfall followed the seeding. However, fince the rain fell in many areas besides those seeded, there is no way of knowing whether the rainfall would have occurred anyway, and in what amounts.

Civilian weather scientists almost universally favor limiting or banning military operations in which weather modification techniques are used, and they can point to a fairly long history of recommending same. In 1971, a National Academy of Sciences (NAS) study of the future of the atmospheric sciences resolved that:[4]

The U.S. Government is urged to present for adoption by the United Nations General Assembly a resolution dedicating all weather modification efforts to peaceful purposes and establishing, preferably within the framework of international nongovernmental scientific organizations, an advisory mechanism for consideration of weather-modification problems of potential international concern before they reach critical levels.

One of the most prominent meteorologists is Thomas F. Malone, of the University of Connecticut, who is chairman of the NAS panel on weather modification of the academy's Committee on Atmospheric Sciences and one organizer with the World Meteorological Organization of the United Nations of the Global Atmospheric Research Program (GARP). Malone says, "I have made speeches for 10 years saying we should get together and do this work internationally before it got to the point of being operational. Otherwise we will face horrendous political problems . . . putting the genie back into the bottle."

Joanne Simpson, who has made cloud modification experiments at the Experimental Meteorological Laboratory of the National Oceanographic and Atmospheric Administration (NOAA), was asked how she would react to seeing the results of her work applied in warfare. She said, "I would be grieved to see my work used for military purposes because I got involved in this kind of work to do useful things, not destructive things."

And Joseph Smagorinsky, a NOAA meteorologist who has modeled climate and weather and who is on the executive committee of the GARP organizing

[3] The civilian experiments which would parallel this activity are reported in "Seeding Cumulus Clouds in Florida: New 1970 Results" by Joanne Simpson and William L. Woodley (*Science*, 9 April 1971). See also *Science*, 7 May 1971, for a general review of weather modification progress.

[4] *The Atmospheric Sciences and Man's Needs: Priorities for the Future*, Recommendation III-6, Committee on Atmospheric Sciences, National Research Council (National Academy of Sciences, Washington, D.C., 1971) p. 61.

committee, expressed stronger opposition: "These programs are a cooperative effort of many nations, and each gives up a certain amount of autonomy to work together," he said. "If they felt this would be used against them, there would very definitely be a cooling off." Smagorinsky pointed out that one part of the GARP plan will put about 20 ships and 10 to 15 airplanes over the Atlantic working together. They will come from many countries, including the United States and the Soviet Union. If it turns out that the United States has militaristic uses for weather modification, "this sort of thing would drop dead. It would undo everything that science has been able to do. It would have absolutely tragic effects."

Walter O. Roberts, director of the National Center for Atmospheric Research in Boulder, Colorado, takes a more conservative view. "I think it very unlikely that deliberate weather modification is a particularly effective weapon," he said. "I'm very concerned about international, inadvertent weather modification as a result of pollution; I don't consider meteorological use in warfare as much of a threat. But if you could visit a hurricane on somebody, I would be very opposed and consider it very serious."

Concern over the military aspects of weather modification has been expressed by a number of defense specialists and arms control experts. Many see a parallel with chemical and biological weapons, which have similar inadvertent effects on environment, and also affect both soldier and civilian. Leslie Gelb, now of the Brookings Institution, who directed from within DOD the 47-volume Pentagon study of the war, which was later leaked as the Pentagon Papers, said, "My instinctive reaction to the use of this kind of technique is negative. Like chemical and biological weapons, it deals in an area that would become essentially uncontrollable. But I have no categorical answer on it because I don't know enough of the scientific aspects."

Representative Gude, who with Cranston, has attempted to find out about Indochina weather control for over a year and has never even been offered a DOD classified briefing, says, "There's a similarity between chemical and biological weapons and weather control. You could have a snowballing effect in both cases, an effect on nature over which you lose control."

Matthew Meselson, professor of biology at Harvard, and a long-time consultant to the Arms Control and Disarmament Agency, who is identified with the successful campaign to ban biological warfare, was asked about the parallel to chemical and biological warfare. He said, "First, I have no knowledge one way or the other as to whether the United States has engaged in weather modification in connection with military activities in southeast Asia.

"However, it is obvious that weather modification used as a weapon of war has the potential for causing large scale and quite possibly uncontrollable and unpredictable destruction. Furthermore, such destruction might well have a far greater impact on civilians than on combatants. This would be especially true in areas where subsistence agriculture is practiced, in food deficit areas, and in areas subject to flooding."

Leonard S. Rodberg, a fellow of the Institute for Policy Studies who assisted in publishing the Gravel *Pentagon Papers*, said, "I don't think we have a right to experiment on other people. It's a standard issue which in medical terms would be called informed consent. The people in that area [Indochina] are totally dependent on the weather for their livelihoods. If we change the pattern we destroy their ability to exist. We've done it not only with weather modification but with defoliants and herbicides." Rodberg adds, "It's quite clear that many kinds of experimentation have been permitted in Indochina. So long as it's not a large operation that would get a lot of publicity, anything can be done."

Most of those queried favored some sort of ban on military uses of weather modification technology. But Adrian S. Fisher, deputy director of the Arms Control and Disarmament Agency from 1961–1969, now dean of the Georgetown University Law School, says, "Weather modification is really an appropriate subject, not only for an arms control agreement, but for a peaceful uses agreement," which would "regulate allocation of resources in such a way as to recognize its good qualities as well as its bad ones."

Finally, another well-known arms control specialist, Herbert P. Scoville, Jr., favors a ban on weather modification's military uses. "I would strongly support any statement that we ought to ban the use of weather modification for military purposes and seek an international agreement on this.

"At some stage of the game, somebody may start doing it—even if it's not going on now. To me it is a terrible way to be using science."

[From Science magazine, Vol. 177, July 21, 1972]

TECHNOLOGY IN VIETNAM: FIRE STORM PROJECT FIZZLED OUT

(By Deborah Shapley)

The Advanced Research Projects Agency (ARPA), which is attached to the Department of Defense (DOD) made at least three attempts, in 1965, 1966, and 1967, to light what defense planners termed "fire storms"—the name used to describe the World War II holocausts at Hamburg, Dresden, and elsewhere—in some of South Vietnam's most valuable timber country. All three attempts, however, fizzled out. One may have even caused rainfall instead of a big forest fire.

The attempts were known by such euphemistic names as Sherwood Forest, Hot Tip, and Operation Pink Rose. They took place in the Mekong Terrace section of South Vietnam—a central plains area which contains several luxury timbers, such as mahogany and rosewood, and half of South Vietnam's sawmills. Timbering is said to be one of the few industries that could develop into prime importance for the South Vietnamese economy. Nonetheless, experts from the U.S. Department of Agriculture (USDA) were called in by ARPA to advise on how to effectively burn the forests. The project's budget was on the order of $1 million.

Military sources say that the attempted jungle fires took place in areas where there were no "permanent type villages," although they allow that Viet Cong supply depots and base camps were in the woods. But Senator Gaylord Nelson (D–Wis.) views the fire projects as part of the U.S.'s "callous" and "unprecedented environmental warfare" which has involved "an outrageous use of technology."

The USDA fire service role in the project was led by Craig Chandler, a fire storm expert who is now director of fire research for the Forest Service. The fire storm project is also discussed in a classified paper, obtained by *Science*, written by Arthur F. McConnell, Jr., a lieutenant colonel in the Air Force who was involved with the Ranch Hand defoliation missions.

Two reasons were given for the project. One was that, by creating a fire which would "crown," that is, burn out defoliated tops of trees, the fire would remove layers of jungle canopy and make reconnaissance from the air more effective. A second reason was that a large-scale jungle fire which reached the tree tops would also destroy the ground cover and make concealment and camouflage by the enemy from U.S. bombing strikes or ground attack impossible.

Fire storms can be many times more dangerous than regular fires; they have occurred accidentally in forests in the American West, as well as in Australia and southern France; they also occurred in urban areas, including Dresden and Hamburg, and on at least two occasions in Tokyo during a 1923 earthquake and during bombing raids in 1944–1945.

In a fire storm, the area of intense burning sucks in oxygen at such a rate that high-speed, cyclone-like ground winds are created, blowing into the fire at speeds which may exceed 100 miles an hour. The Hamburg fire chief, for example, reporting on the fire storm of July 1943, said that many people died from the intense heat even though they were located 150 meters from the nearest burning building.[1]

Both McConnell's classified paper (which was later sanitized and published in the *Air University Review* [2]) and ARPA officials used the term fire storm to describe the burning projects in Vietnam. Chandler says he was asked on a number of occasions during the operation of the project whether a fire storm could be ignited in the humid, tropical jungle. Although lighting a fire storm might be feasible under certain conditions in temperate areas, such as the western United States, Chandler said he told the military it was not feasible to do so in the jungle.

Nonetheless, the fire storm project, as it came to be known, was started under ARPA authorizing order 818. Its final reports are all classified, although some press reports appeared at the time of the attempts. Chandler said he was willing to be interviewed only about those aspects of the project which he had already seen appear in unclassified publications.

The project began at the request of CINCPAC, the office of the Commander in Chief of the Pacific which runs operations in Vietnam. Chemical defoliants were then coming into use in the war. However, the jungle canopy, which can extend upward in tiers to a height of 100 feet from the ground, was not transparent enough after defoliating missions. An ARPA spokesman said, "The question posed

[1] "Field notes on World War II German fire experience," title of contract No. N228(62479)–65419 to Carl F. Miller and James W. Kerr, October 1965, Stanford Research Institute, Menlo Park, Calif.

[2] The sanitized version was published as: A. F. McConnell, Jr., "Mission: Ranch Hand," *Air Univ. Rev.* 21, 89 (1970).

by CINCPAC was: couldn't we burn the jungle area in the so-called 'hot zones' of infiltration?"

ARPA hired the fire research section of the USDA Forest Service to carry out the order, and offered the support of its 25-member field unit which had been stationed in Vietnam since 1961. The USDA did some preliminary research, then participated in the first "field test"—as ARPA calls it—in the Boi Loi woods near the Iron triangle near Tay Ninh city. The area is due west of Saigon, close to the Cambodian border. As in all the fire storm attempts, at the beginning of the dry season Ranch Hand crews defoliated the area, the dead leaves were permitted to dry out for a period, thus preparing the fuel supply. Then ignition was attempted. Hence, in April or May of 1965, a section of the Boi Loi woods was ignited. According to McConnell's paper, the project, "Operation Sherwood Forest," was "a massive attempt to burn out a defoliated section of the Boi Loi woods in the hope of denying the enemy an extremely vital base camp area."

Unfortunately, it was raining on the day the field units tried to light the fire. The lighting attempt went ahead, but nothing happened because of the rain. The failure to ignite the woods under the right weather conditions was the reason a second attempt was made a year later.

Chandler recalls two subsequent major attempts, but McConnell's paper implies that there may have been more. "It is interesting to note," McConnell wrote before the Air Force censor deleted the passage, "that during this period and for the next year, several 'fire storm' projects similar to the Boi Loi woods effort were made in conjunction with the Vietnamese Air Force." Asked about this, ARPA officials noted that one of the jobs of the ARPA field unit was to transfer technical skills to the Vietnamese; however, the officials doubted that the incendiary technology was ever successful enough to be passed along to U.S. allies.

The second major burning attempt, code named Hot Tip, was made much farther north, in the Chu Pong Mountains, about halfway between the South Vietnamese cities of Pleiku and Kontum. Ranch Hand crews again defoliated a forest tract probably less than 30 square miles in area. Chandler recalls that the fire was lit sometime in either January, February, or early March of 1966.

"This one wasn't done in the rain," says Chandler. "It was more successful than the first attempt. We recommended some changes afterward, which is why there was a third attempt." Later, an Associated Press account termed this attempt an "incendiary raid" made by "tactical bombers." According to other sources, the fire burned parts of the forest and ground cover, but failed to continue burning, or to spread. One reason, of course, was the high humidity of the jungle. The other was apparently the temperature and wind conditions.

The third and biggest attempt, code named Operation Pink Rose, took place in a Viet Cong stronghold northeast of Saigon near Xuan Loc, in February or early March of 1967. The area staked out for burning was probably 30 square miles. In this case, although weather conditions were perfect, the fire was followed by a rainstorm which put it out. Some accounts say that the fire may have caused the rainstorm. Thus, all three of the attempts were considered failures.

According to McConnell's original paper, in a passage that was later slightly altered: "One of the highlights of this period [early 1967] was Operation 'Pink Rose,' the third jungle-burning project carried out by Ranch Hand crews. In support of this project, the squadron flew approximately 225 sorties and delivered over a quarter-million gallons of herbicide on selected target areas in War Zones C and D." One military observer, L. L. Herzog, a lieutenant commander, who saw the Pink Rose incendiaries dropping from the sky, was later quoted as saying, "It looked just like the Fourth of July."

Chandler says, "The rain came the evening afterwards. The country doesn't burn well. This is why there was never any expectation on our part that fires were going to spread." Chandler would say only that the incendiaries used for Operation Pink Rose were "of a World War II type" and that after the third attempt, the Forest Service experts who had worked on the project wrote a report to ARPA advising that no further "field tests" or research be carried out.

Much of ARPA's field research in South Vietnam, including the trail sensor network and the foliage penetration radar, has come into wide use in the war. Other projects, such as Pink Rose, which don't work out, are allowed to quietly die. "This was clearly one of those ideas that should have been given the very quietest funeral," an ARPA official said. ARPA briefed the relevant officials in the Air Force and the Office of the Secretary of Defense on USDA's conclusions, and that was that. "Its really was a nutty idea to begin with," said an ARPA official.

Despite the unanimous "nyet" of the USDA and ARPA to the feasibility of starting fire storms, or self-propagating fires, in the damp Vietnamese jungle, two questions about the project remain. One is why the term fire storm came to be applied in the first place to the project. McConnell, the former Ranch Hand chief who mentioned fire storms in the course of his paper, said he recalled picking up the term from military sources.

Jay Bentley, a forester, now retired, who was with the fire research service, and headed up the fieldwork for Hot Tip, the second attempt, said he did not recall even hearing the term fire storm in connection with the project until he read it in the newspapers. As to who raised the expectation that a Dresdenor Hamburg-like holocaust would be created in the jungles, Bentley says, "I didn't expect very much to result or think the expectation was very high as far as ARPA was concerned." This statement, as well as ARPA's skeptical attitude toward the project, would seem to imply that the enthusiastic—and horrific—term fire storm emanated from military command sources, over the expert technical advice of the civilians and ARPA.

Another question is what would have happened if the experts had indeed found a way to spark big fires. ARPA sources said unhesitatingly that if Pink Rose had succeeded, the military commanders would have doubtless gone on to use fire-lighting in other situations.

Incendiary technology would have been added, along with herbicides, weather modification, and other environmental weapons, to the DOD arsenal.

Yet, discussing their own role, both the ARPA spokesmen and the Forest Service experts merely claim that they were giving neutral, technical advice. Chandler obviously likes trees, yet he also supports the jungle-burning project because, in his words, "it was part of a military operation" and no villages "friendly or unfriendly" were involved. "This was definitely not a burn-up-people project," he says. And a high ARPA official defends the agency's role thus: "Here was a situation which came up which clearly no one knew what the facts were. . . . We were, as research people, asked to look into the technical possibilities and to tell people who make political decisions what the facts were." These statements rivet the issue back to the historic claim by scientists that their technical advice is morally neutral and, by implication, divorced from the uses to which the technology they develop is ultimately applied. Perhaps there were no villages involved in what ARPA blandly called the "field tests" of the incendiary projects. Yet clearly there was no insurance that villages would not someday be included in the target area.

The fire storm project is now a mere historical event which its perpetrators would prefer to forget. But another issue may loom very much in the present and future and relates to the matter of ecocide. According to Forest Service experts who have surveyed and inventoried the forest resources of South Vietnam and their alteration due to the war, at least 1 million hectares were defoliated, as of 1967, and that total may have reached 3.5 million by 1969.[3] Defoliation has taken place, not just a few times in a few strategic patches of jungle; some areas have been sprayed for almost 10 years. The tropical hardwood forests of the Mekong Terrace are drier now than they were in 1965–1967 when humidity dampened Pink Rose projects. It is still possible that fires might recur as a mode of warfare in the collective memory of CINCPAC and the military commanders. As one ARPA official said, "If the system has any institutional memory whatever, if this suggestion is ever made again, they'll look into the files and find out it doesn't work."

SIERRA CLUB,
San Francisco, July 20, 1972.

President RICHARD M. NIXON,
The White House,
Washington, D.C.

DEAR MR. PRESIDENT: It has been revealed only recently that the United States government has been using weather modification as a weapon of war in southeast Asia. We protest both the unilateral escalation of weaponry and the perversion of environmental forces by their use as instruments of warfare. These are forces that have the potential of doing mankind untold good.

This action by our government is a clear violation of the principles of the Declaration of the United Nations Conference on the Human Environment adopted in Stockholm on June 16, 1972, to which the United States is a party.

[3] Barry R. Flamm and Jay H. Cravens, "Effects of war damage on the forest resources of South Vietnam," *J. Forest.* 69, 784 (1971).

This Declaration stated that:

"States have, in accordance with the Charter of the United Nations and the principles of international law, . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."

The revelation that we use weather modification as an instrument of war raises serious question as to our good faith in entering into this solemn compact and our intention to abide by it.

We believe that such environmental modification activities can have significant unforeseen consequences with widespread and perhaps uncontrollable damage.

We the public have not been informed of the reason for using environmental engineering as a weapon of war any more than we were of its use until the recent publications. But, even if it has been effective, which we do not see claimed or substantiated, the United States should seek to lead the world's nations away from new armaments, not towards another arms race. The use of weather modification as part of such a race would be particularly tragic because meteorology has been a model of international cooperation.

Accordingly, we call upon you to announce that the United States will seek international agreement on the principle of providing for the complete cessation of any research, experimentation, or use of any environmental or geophysical modification activity as a weapon of war. The United States should henceforth dedicate all geophysical and environmental research to peaceful purposes and should actively seek the cooperation of other nations in programs of joint research on geophysical phenomena, their control, and their peaceful use.

RAYMOND J. SHERWIN,
President, Sierra Club.
MARVIN L. GOLDBERGER,
Chairman, Federation of American Scientists.

ENVIRONMENTAL IMPACT OF MODERN WEAPONS TECHNOLOGY IN S.E. ASIA

(By E. W. Pfeiffer and Arthur H. Westing, Copyright 1971, Committee for Environmental Information)

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The following three reports on Vietnam were prepared for *Environment* by two U.S. scientists who have had considerable experience in that country. They are Dr. E. W. Pfeiffer, zoologist from the University of Montana, and Dr. Arthur H. Westing, botanist from Windham College, Putney, Vermont. Both scientists had previously traveled to Vietnam to investigate the effects of wartime use of herbicides (see *Environment*, March 1971, p. 34). In August, they visited Vietnam on behalf of the Scientists' Institute for Public Information and *Environment*; their trip was supported in part by the Fund for Investigative Journalism and the D. J. B. Foundation. They explored, among other things, ways in which the landscape has been drastically altered by high explosives, including 7.5-ton bombs, and special bulldozers. (Previous reports dealt with the effects of herbicide spraying.)

In summary, the investigations reveal that military operations in Vietnam have disrupted the economy and cultural life of the people, as did saturation bombing and mechanized armies in Europe in World War II. For the most part, the high explosives used in the Indochina War have devastated the land rather than major cities, but the destruction has seriously damaged forests and soil on which the Vietnamese depend. For example, bulldozers equipped to clear jungles to the forest floor and thus deny cover to the opposing soldiers have already destroyed more than $40 million worth of timber and rubber trees. Timber not destroyed outright frequently contains shrapnel that either breaks saw blades or promotes disease that weakens the wood. In the wake of jungle-clearing operations come soil erosion, flash floods, and invasion by economically useless weeds. The estimated ten million or more bomb craters in South Vietnam disrupt rice farming and fill with water to become breeding places for disease-bearing mosquitoes. Special blockbuster bombs—the largest aerial weapons available short of nuclear weapons—uproot all vegetation in football-field-size areas and kill or injure all animal life for almost a mile in every direction. An as yet undetermined cost of the war will be the long-term ecological and sociological effects of this devastation.

I. Craters

(By E. W. Pfeiffer)

During the Indochina war the U.S. has dropped more than two times the tonnage of bombs that was dropped in Europe, Asia, and Africa during World War II, most of it in Vietnam, a country about the size of New England or one-half the size of the state of Montana. Rockets, artillery shells, and mines have been exploded on a vast scale in many areas in Vietnam, in addition to explosives dropped from aircraft. This ordnance has been used principally in free-fire zones or special strike zones, which all people except the National Liberation Front and its North Vietnamese allies have supposedly vacated. Data on the extent of the free-fire zones of South Vietnam would permit calculation of the percent of Vietnamese land surface that has been intensively subjected to these weapons. These data are not, however, presently available.

Although few details have been released regarding expenditures or target locations for the various types of munitions, the following summary figures for all of Indochina have been made available by the Department of Defense:

MUNITIONS USED IN INDOCHINA WAR

[In millions of pounds]

Year	Air munitions	Surface munitions	Total
1965	630	?	630
1966	1,024	1,164	2,188
1967	1,866	2,413	4,278
1968	2,863	3,003	5,866
1969	2,774	2,808	5,583
1970	1,955	2,389	4,344
Total	11,112	11,777	22,889

We do not know what fraction of the 23 billion pounds of munitions expended during these six years was small arms and other ordnance that would not produce craters (nor do we know what the distribution is among South Vietnam, North Vietnam, Cambodia, and Laos). To make some wild assumptions, if half the minitions (by weight) were of the sort that produce craters (bombs, shells, etc.) and if each was a 500-pound bomb, then Indochina's landscape would now be more or less permanently rearranged by more than twenty million craters. Using an estimated average diameter of 30 feet, the holes alone would cover a combined area of about 325,000 acres. Although occasional, scattered craters can be found almost anywhere in rural South Vietnam, we have observed large areas of severe craterization in the provinces of Tay Ninh, Long Khanh, Gia Dinh, Hau Nghia, Binh Duong, Quang Ngai, Quang Tin, and Quang Nam. We have been told about similar areas in Kien Giang, An Xuyen, and Quang Tri. No type of habitat seems to be spared, including forests and swamps, fields and paddies. Many severely craterized areas—such as the so-called free-fire zones, free-bomb zones, or specified strike zones—were formerly inhabited and farmed. Such regions of important military activity as War Zones C and D, the Iron Triangle, the Rung Sat and U Minh Special War Zones, the Demilitarized Zone, and the Ho Chi Minh Trail are among those regions that have been subjected to repeated saturation or pattern bombing.

What is this unprecedented bombardment doing to Vietnam and its people? In order to make a preliminary assessment of the effects of these explosives Arthur H. Westing and I visited Vietnam in August 1971. In preparation for our trip we had sought information from many sources on effects of bomb craters resulting from military activities, but were unable to find any significant information.

We flew over bombed areas in helicopters and rode in armored personnel carriers to observe at first hand craters from B-52 strikes. We interviewed in the field Vietnamese farmers who were trying to reclaim bombed land, Vietnamese loggers who were operating in bombed and shelled areas, and several Vietnamese and American officials.

In order to judge the magnitude of the problem it is necessary to have some idea of the number of bombs dropped and the amount of territory affected. Earlier studies have presented data which suggest that some 7.5 million craters have

been formed as a result of the massive bombardment. Although we estimate that the current figure for South Vietnam is in excess of 10 million, we are currently awaiting Department of Defense data to verify this figure.

The standard weapon of the B–52s is a 500-pound bomb; each B–52 carries 108 five-hundred pound bombs. Each bomb produces a hole 20 to 50 feet wide and 5 to 20 feet deep, depending on soil conditions. The bombs are usually dropped from over 30,000 feet by the B–52 aircraft and can have sufficient force on impact to penetrate deeply into certain types of soil.

Severely bombed areas observed on our trip included the following land types: heavily cultivated areas of the Mekong Delta, intensively cultivated mountain valleys in the northern region of Vietnam, mangrove forests, evergreen hardwood forests of the flat terraces northwest of Saigon, and evergreen hardwood forests of the precipitous mountain areas in the Da Nang-Quang Ngai area.

Because of the war situation at the time of our visit, we were unable to fly over, even at high altitude, the most intensively bombed regions of South Vietnam which lie in the northwest corner of the country and along the Demilitarized Zone. We were also very disappointed to find that security problems made it very difficult to visit on foot bombed areas in all of the regions that we attempted to study. It is important to note that there are areas of South Vietnam, particularly in the delta region, that do not reveal, at least from the air at 3,000 feet, much evidence of war damage. Large areas, however, have been hit very intensively by several types of ecologically devastating weapons.

What are the effects of the massive bombardments on cultivated areas such as the Mekong Delta? Our observations made both in wet and (on previous visits) dry seasons show that in the delta the B–52 craters and those caused by large artillery shells are permanently filled with water, probably because the craters penetrate the water table. In many areas waters of different colors fill adjacent craters. Some of the waters in the craters are aquamarine while others have a more bluish to greenish tint, and many are simply a muddy brown. These differences in coloration are apparently due to growths of varying types of algae. It is interesting that different growths occurred in contiguous craters.

I was able to visit on foot three such craters in an agricultural area about 30 miles south of My Tho in the heart of the Mekong Delta. The area, near the hamlet of Hoi Son, had been a free-fire zone until fairly recently, but farmers were now being resettled on their land because senior officials considered the region relatively secure. The degree of security became evident: During my stay in the area U.S. aircraft were rocketing and strafing only a few miles away. I interviewed some families who had left the area eleven years ago because of the fighting. They took me to three craters made in 1967. I would estimate that they were caused by 500-pound bombs dropped by fighter bombers. Each crater was about 30 feet in diameter, filled with water and, at the time of my visit, about 5 feet deep in the center, as proven by one of my guides. He waded into the center of the crater where he could just manage to keep his nose above water while standing. The entire immediate vicinity had been a rice paddie; the rice had been replaced by a very tall reed (6 to 8 feet), genus *Phragmites*, which surrounded the craters at a distance of 10 to 20 feet. Growing from the rim of the craters and into the reeds was a species of relatively short grass, genus *Brachiaria*. A taller grass, *Scirpus*, was also prevalent. The whole area was inundated by very shallow water, as it was the middle of the wet season. The farmers were growing seed rice near the craters and were plowing under the reeds and grasses in preparation for planting rice. It was obvious that they could not use the cratered areas for rice cultivation, because the water was much too deep. One solution to the problem is to bring in soil from elsewhere. Although I could not confirm it, one farmer said that the craters I observed yielded exceptionally good fish catches. The fish presumably had moved into the craters during the monsoon flooding. Surrounding the area that had been cultivated in rice were banana, coconut, and jackfruit trees. The jackfruit was dead as a result of herbicides; the coconut trees were destroyed by the bombing, leaving only bare stumps.

In our conversations with these and other farmers who were trying to resettle their fought-over land, it became obvious that their main problem was the presence of unexploded munitions in the areas. The Hoi Son people stated that within the last few weeks three women had been killed and one badly wounded when plows detonated unexploded weapons. We learned that mines in some resettled areas have been cleared, but the problem of locating and neutralizing unexploded ordnance before land is resettled is an urgent one. On several occasions we encountered the fear of unexploded munitions, which probably accounts for a phenomenon we often observed from the air: fields with craters were usually not being cultivated although nearby fields were. One farmer whom we interviewed

stated that the people do not like to plow in the bombed areas because the shrapnel in the dirt cuts the buffalos' hoofs, resulting in infection.

According to science spokesmen of the U.S. Agency for International Development (USAID) and the Military Assistance Command, Vietnam (MACV), bomb craters are sometimes used as sources of freshwater for irrigation. In much of the southern Mekong Delta, brackish (salty) water floods cultivated lands at high tides if it is not kept back by dikes. Thus, irrigation is necessary and freshwater in the craters could be useful.

Presumably the permanently water-filled crater areas of the delta region are excellent breeding grounds for certain species of mosquitoes and other carriers (vectors) of disease. Those craters not invaded by predators of mosquito larvae provide conditions for greatly accelerated reproduction of mosquitoes and other vectors. According to MACV-Command Information pamphlet 6-70, February 1970, "malaria has been causing increasing concern in Vietnam. . . . Up until recently it (*Plasmodium falciparum*) only affected regions of I and II Corps but has now spread to other areas throughout the country." We discussed with several scientists the possible relationship between craterization and this increase in malaria, but no studies have yet been made of this problem as far as we could determine. A USAID specialist in public health with headquarters in Saigon stated that the current alarming increase in hemorrhagic (dengue) fever seen in the Vietnamese was *not* related to craterization because the mosquito vector for this disease, *Aëdes aegypti*, lives only in and around houses and would thus not be affected by ecological changes such as craterization. (We do not know of any field research which supports this view.) We flew a mosquito-control spray mission in a C-123 aircraft from which malathion was being sprayed (one-half pound per acre) over and around an Australian military base. There are only two aircraft now carrying out this program, and, as far as we were able to determine, there is no spray program involving treatment of cratered areas.

We observed many craters in isolated mountain valleys near Da Nang. They were in small clusters in mountain rice fields and thus were probably caused either by artillery or fighter-bomber strikes and not by B-52s. In these valleys the craters were generally filled with water as in the delta, but they probably are without water in the dry season and thus cannot be used for fish culture. The paddies that had been cratered were not being cultivated. During our visit we flew over many rice paddies with ponds in the centers almost comparable in size (about ten feet across) to the bomb craters, but these were fish ponds and apparently did not interfere with the cultivation of the rice surrounding the ponds. It is thus unlikely that scattered craters could create changes in soil moisture or other conditions that would make cratered paddies uncultivatable.

We observed from the air large areas of the mangrove swamps of the Rung Sat Zone which had been subjected to very heavy B-52 strikes. These are all permanently water-filled and obviously would make transportation into the area very difficult. This could be of some significance because the mangrove forests have been regularly used as sources of wood for charcoal and for fishing grounds.

We observed many craters at first hand in the Boi Loi woods area. This had been an evergreen hardwood forest on the flat terrace northwest of Saigon. Most mature trees were dead from defoliation (herbicide spraying) but there was a very thick understory of useless broadleafed brush, vines, bamboo, and *Imperata* grass reaching a height of 15 to 20 feet. Craters were very numerous in this area and were scattered at least every 100 feet or so. Each crater was 20 to 30 feet across and 5 to 10 or more feet deep. They were all in a grey podzolic soil (a poor soil often formed in cool, humid climates) with poorly defined horizons (layers). There were many generations of craters. The most recent ones were bare of vegetation but contained a little rain water at the bottom. In the older ones a few sprigs of grass, probably *Imperata*, were sprouting in the center. (We also noted the begining of plant growth in the center of some of the water-filled craters in the delta.) As the craters age the grass grows radially, covering the bottom, and finally grows up the sides to meet vines growing down from the peripheral vegetation. There is some filling of old craters with soil washed down from the sides, but this is limited because old craters completely covered with grass were still 5 to 10 feet deep. We did not observe any broadleafed plants invading these holes.

We were able to learn something of the effects of saturation bombing and artillery fire upon forest timber resources through interviews with loggers and sawmill operators and by inspection of damaged logs, mainly in the Ben Cat and Chon Thanh areas. We also interviewed South Vietnam forestry officials about the problems of utilizing bombed forest areas. These officials indicated that

loggers do not like to operate in bombed timber because the trees have metal fragments in them which greatly reduce the value of the logs. (One logger estimated that the price of logs containing metal is reduced by 30 percent.) We could understand the reason for the reduced value when we observed piles of saws with teeth ripped out and examined discarded logs from which we dug pieces of metal. In some logs there were dead areas about twelve inches in diameter and six inches deep from which we recovered bomb fragments. We learned that when mature timber is punctured by metals such as steel shards or bullets, entry is provided for disease organisms, probably fungi, which result in dead areas that increase in size as the wound ages. Thus, largely unlike trees in temperate zones, the trees of Vietnam are susceptible to rot when penetrated by metal. This greatly decreases the value of the timber and also weakens trees so that they are much more subject to being blown down. An official of a French rubber plantation told us that he had lost many rubber trees on his plantation because the trees had been weakened by fungus infection following bomb damage and then blown down in one of the frequent violent wind storms that occur in the area. The loggers whom we interviewed said that the craters in the forest made passage very difficult for trucks and loaders, a situation that necessitated cutting much shorter logs than desirable in such areas. (We saw 90 foot logs coming out of undamaged forests.)

We were able to observe from a high-flying helicopter the craters caused in a mountain forest near Da Nang by a B–52 strike about one and one-half years earlier. The craters were still obvious on the mountainside and along the ridges. The large burned areas in these forests appeared to be even more significant; they had apparently resulted from fires started by various types of ordnance such as white phosphorus, napalm, and flares.

We tentatively conclude that those cultivated areas hit heavily with conventional high explosives will be very difficult, if not impossible, to recultivate. They can perhaps be used as fish-rearing ponds or, in certain situations, as sources of freshwater for irrigation. They may provide additional breeding areas for insect vectors of disease. In the forested areas that have not been killed by chemical defoliation, the bombing has created problems that are probably just as great as those caused by defoliation. However, the immediate problem of greatest concern is the vast number of unexploded mines, bombs, rockets, and so forth, that must be removed if the land is to be resettled. Since the Department of Defense reports that approximately 1 to 2 percent of our air and ground munitions fail to explode, there are several hundred thousand of these randomly buried throughout Indochina.

We recommend studies to determine the relationship of water-filled craters to the spread of certain deseases and to determine how cratered areas can best be rehabilitated. We also recommend that greatly expanded operations be initiated to locate and neutralize unexploded ordnance in agriculturally useful areas.

II. Leveling the Jungle

(By Arthur H. Westing)

Despite the lavish application of great wealth and superior technology, the U.S. has made surprisingly little headway over the years against the National Liberation Front and its North Vietnamese allies. With the growing realization that the forest functions as a key ally of guerrilla fighters by providing cover and sanctuary, more and more effort has been directed toward its obliteration. For a number of years reliance was placed primarily on chemical destruction. This approach reached its peak in 1967, but largely because of pressure exerted by the scientific community, it now not only has been reduced to a low level (see *Environment*, July/August 1970, p. 16) but also has been entirely "Vietnamized." The herbicidal assault has left South Vietnam with a legacy of many millions of dead, now rotting trees, and with locally debilitated ecosystems. A second approach that has been employed through the years to make the forest less hospitable to the other side is a bombing and shelling program of incredible magnitude. The 23 billion pounds of total munitions expended in Indochina between 1965 and 1970 alone are more than double those used by us throughout World War II in all theaters.

In recent years, however, a new technique has emerged. Born about 1965, developing into major proportions in 1968, and growing ever since, a vast program systematic forest bulldozing now exists. The U.S. Engineer Command in Vietnam is daily putting Hercules and his twelve labors to shame. This report outlines the methods, scope, and magnitude of this "jungle eating" program and speculates on its economic and ecological impacts.

The basic tool of the landclearing operations in Vietnam is the 20-ton D–7E Caterpillar tractor fitted with a massive 11-foot wide, 2.5-ton "Rome plow" blade equipped with a special 3-foot splitting lance or "stinger," and with 14 tons of added armor. A very limited number of the even more immense D–9 tractors are also in use. More than twice the size and weight of the D–7, each of these machines is said to be the operational equal of several. The tractors are presently organized into five companies of three platoons each, each company operating 30 or more tractors. Unofficially, the companies go under such names as Rome Runners, Land Barons, and Jungle Eaters. These outfits bulldoze continuously from dawn to dusk, seven days a week under what can only be described as spine-twisting and gut-wrenching (to say nothing of dangerous) conditions. No tree appears to be too large and no jungle too dense to escape these powerful machines in what must certainly be the most intense land-claring program known to history.

The bulldozing began on a very small scale in 1965 and was devoted primarily to the clearing of roadsides and other lines of communication in order to discourage enemy ambushes. It was not until mid-1967 that the tractors were organized into small units. By the beginning of 1968, most of the major road systems in the central half of South Vietnam (Military Regions II and III) had already been cleared. Although this mission still continues, virtually all major roads in the country have now been cleared for 300 to 600 feet or more on each side. These swaths throughout forest and plantation are now a conspicuous feature of the Vietnamese landscape. In some instances chemical herbicide treatment has helped to maintain these strips in a treeless condition.

The employment of massed tractors organized into companies for extensive forest clearing began in 1968, and the program has expanded ever since. In its primary mission of denying forest cover and sanctuary, the "Rome plow" appears to be without equal. Effectiveness of the tractors is clearly superior to that of aerial application of chemical antiplant agents. The devices are considered, for example, to be playing an instrumental role in the attempt to "secure" the region centered around Saigon (Military Region III). They are also of considerable importance in the northern half of the country (Military Regions I and II). The U.S. has outfitted and is training two Vietnamese landclearing companies as one of the facets of "Vietnamization."

We were able to spend one day in action with the 984th Landclearing Company, which at the time was operating in the southeastern corner of Tay Ninh province. During our stay, the company was in the final stages of obleterating the Boi Loi woods. More accurately, it was supplying the *coup de grace* to this longtime enemy stronghold that previously had been treated at least once with herbicides, had been subjected to saturation bombing from B–52 stratofortresses, and had also been shelled by artillery.

We joined the outfit on its twenty-seventh day in the Boi Loi woods. During the past 26 it had already scraped clean 6,037 acres. Several days more and this job would be finished, permitting the 984th to move on to greener pastures. Before this job, the men had eliminated the 9,000-acre Ho Bo woods in nearby west-central Binh Duong province.

The Boi Loi woods was enemy territory and we were dropped in by helicopter. We accompanied one of the platoon commanders in his armored personnel carrier and were flanked by several Sheridan tanks of the Eleventh Armored Cavalry. Although we had no contact with the enemy that day and hit no landmines, we were informed that both were regular occurences. In the past 26 days, for example, several enemy attacks had been repulsed and the tractors had set off no less than 37 mines in the course of their work. (Seven casualties from landmines had been sustained during this period.)

In operation, the tractors were strung out in a long staggered formation, the lead tractor being directed for much of the time by the company commander circling overhead in a small helicopter. The large number of bomb craters made the job of maneuvering the large tracked vehicles most difficult. The heat was oppressive (hovering around 130 degrees F. in the tractor cabs) and the work was truly arduous. But the morale of the men seemed very high, despite their fifteen-hour work days, seven days a week, wet season and dry. The company was proud of its abilities and accomplishments and, we are told, was among the rare units in Vietnam without a drug problem.

At the time of our visit, the unbulldozed terrain was covered largly by a tangle of head-high, broad-leafed brushy plants and vines intermingled with *Imperata* grass and shrubby bamboos. Of the scattered trees, more than half were dead. The plow blades were set to skim the surface, each tractor scraping bare almost an acre per hour. The big trees came crashing to the ground with great regularity.

Most were simply pushed over, but the really large ones were first split by the stinger.

The terrain was flat and the soil a heavy grey podzolic, so that neither erosion nor laterization (hardening of soils to a brick-like substance) are likely to be problems here. In view of available seed (or other reproductive plant parts) and shadeless conditions, this area is likely to be quickly dominated by a combination of *Imperata* grass and shrubby bamboos, thereby largely precluding reforestation for years (perhaps decades) to come. In other areas we inspected in Binh Duong province that had been bulldozed two or three years previously, by far the most prevalent vegetation was the worthless and pernicious weed *Imperata*. Indeed, of the thousands of acres of formerly bulldozed areas that we were able to see on this and our previous visits, there was only one area where forest trees (a commercially low-grade species of *Dipterocarpus*) were recolonizing naturally. Where bulldozing is done in more hilly terrain, erosion can become a severe liability. Moreover, with the elimination of the enormous water-holding capacity of an extant forest, the heavy rains characteristic of Vietnam can produce severe flood damage. We learned of one devastating flash flood in a recently bulldozed area in Khanh Hoa province.

It cannot be denied that there are advantages to the bulldozing, given the conditions of this grim war. First, bulldozing largely clears areas of landmines, an ever-present horror throughout much of Vietnam to all who attempt to re-utilize a war-visited area. (One Vietnamese whom we came to know has so far lost six relatives to mines left behind by one side or the other.) Secondly, some of the timber can subsequently be salvaged, particularly for firewood and charcoal manufacture. Thirdly, some of the bulldozed lands in "secure" areas have been taken over for agricultural pursuits, although this is often not feasible even in such areas because of extensive craterization by explosives. Farming is particularly evident in the roadside strips near population centers. A small fraction of the clearing by bulldozers is actually said to be done with subsequent resettlement or agricultural pursuits in mind (see, for example, *New York Times*, July 15, 1971, p. 3).

Bulldozing has, according to official military sources, leveled over 750,000 acres to date. I estimate that clearing continues at a rate of more than 1,000 acres per day. Because I was unable to obtain a breakdown of land and land use categories that have fallen to the relentless bulldozers, it is difficult to estimate the overall economic loss that can be attributed to these operations. However, some partial indications can be presented. With respect to the timber resource, the South Vietnamese forest service has determined that at least 126,000 acres of prime timber lands accessible to lumber operations have been destroyed through 1970, together with an estimated twenty million board feet of marketable tropical hardwood timber. At recent Saigon market values, averaging about $72 per thousand board feet, this amounts to a loss of $14.7 million. To this sum must be added a future loss due to destruction of growing stock. With respect to the rubber resource, the French rubber interests in South Vietnam have determined that substantially more than 2,500 acres of producing rubber trees (representing just over 1 percent of South Vietnam's total rubber) have so far been destroyed by bulldozers There are about 120 rubber trees per acre, with an average value of $88 per tree. Total loss here can thus be estimated to exceed $26.4 million. (I might add that to the consternation of the French owners, they have received no compensation.)

There are, of course, many other losses attributable to the bulldozer program, most of which are impossible to quantify. Among them can be listed site degradation, erosion, weed invasion, destruction of wildlife habitat, flood damage, and miscellaneous property loss. One recent press report from western Hau Nghia province tells of the obliteration by bulldozers of a still partially inhabited farming region and the consequent disruptive impact (*New York Times*, May 7, 1971, p. 5). Even whole villages have been obliterated (*Nation*, Oct. 23, 1967, p. 397). Discussions with professional Vietnamese foresters revealed yet another headache connected with the landclearing operations. In its nationwide forest conservation program, the South Vietnamese forest service issues timber-cutting permits on a judiciously restricted basis. However, corrupt province chiefs have, during the past year or so, come to realize that a denied local cutting permit can often be circumvented by turning to the Vietnamese Defense Department and, for pretended reasons of military necessity, request that the area be designated for bulldozing. If the request is granted, the chiefs can then cut the timber for personal profit. Finally, another use of the bulldozers results in a small amount of additional and unnecessary damage. In their lighter moments the engineers occasionally

turn to carving up the landscape for the sheer hell of it. Thus one can now find a U.S. First Infantry Division emblem, covering some 1,500 acres, carved into the landscape about 25 miles northwest of Saigon (*New York Times*, Apr. 5, 1970, p. 7); a giant peace symbol is similarly engraved near Hue (*Life* magazine, July 2, 1971, p. 72).

In conclusion, the question is raised—although not answered—of how much forest loss can be sustained by an area before the regional ecology is adversely affected to a substantial extent. Before the war, more than 25 million acres of South Vietnam were covered by forest, representing about 60 percent of the country's total area of 43 million acres. So far, the war has claimed at the very least 3 million acres of the forest cover. The herbicide program has accounted for somewhat more than a third of this, the bulldozing somewhat less than a third, and the bomb, rocket, and shell craters (plus damage from other munitions) the remainder. Although the estimated 12 percent reduction in forest cover may not have a dramatic influence on the overall ecology of South Vietnam, detailed investigation will elucidate the magnitude of the subtle changes that have resulted. In the numerous local areas of severe damage, often covering several thousands of contiguous acres, the repercussions—both ecological and sociological—will be profound.

III. The Big Bomb

(By Arthur H. Westing)

In this report I summarize our findings about a new bomb in the U.S. arsenal, a bomb unique to the Second Indochina War. Owing to the paucity of information domestically available, I describe in some detail the bomb's general characteristics and employment.

The BLU–82/B general-purpose high-explosive concussion bomb turns out to be one of the most awesome and least publicized weapons to have been spawned by the war. It is a bomb with record-breaking dimensions: It is 4.5 feet in diameter, over 11 feet long, and weighs 15,000 pounds. Within its thin steel case are 12,600 pounds of a special, dense blasting agent (DBA–22M) consisting of a gelled aqueous slurry of ammonium nitrate and aluminum powder (plus a binding agent). This formulation provides a concussive blast surpassed only by that of a nuclear bomb.

Often referred to in Vietnam as the "Daisy Cutter" and sometimes as the "Cheeseburger," this super bomb is delivered by C–130E aircraft (of the 463rd Wing of the Seventh Air Force flying out of Cam Ranh Bay air base). Even though the bomb is floated to the ground by parachute from altitudes of 7,000 to 10,000 feet and occasionally even over 20,000 feet, the Seventh Air Force claims that the point of impact seldom is more than 300 feet off target and usually less than 150 feet. Timing of the drop is determined by ground radar.

The Daisy Cutter was developed primarily for the instant creation of clearings in dense jungle. Such clearings can then be used immediately as a landing zone by assault helicopters in locations inaccessible to conventional land-clearing equipment and techniques. The progentitor of this unique bomb was the 10,000 pound "blockbuster" bomb of World War II. Several dozen or more of these bombs were left over from that conflict. These were used in Indochina on an experimental basis, apparently beginning in 1967. The presently used BLU-82/B was developed and became operational in early 1970.

The bomb is detonated by an impact fuse at the end of an attached three-foot probe which sets off the main charge simultaneously at both ends of the bomb just above the ground. If all goes well, the resulting radial blast leaves no crater, but rather uproots and blows away all trees and other obstructions—even in heavy jungle—to create a virtually perfect clearing about the size of a football field. Although the size of each clearing differs, of course, according to local conditions of terrain and vegetation, the average radius of the opening, according to the Air Force, is about 160 feet, and its area thus about two acres. No fires are reported to have been set by these bombs and only minimal charring occurs. The blast is spectacular: A mushroom cloud rises some 6,000 feet into the air, and light aircraft flying more than two miles from the explosion are badly shaken by the shockwave. The landing zone, suitable for landing within minutes of the blast, can accommodate one to several assault helicopters at a time. The military code name for such an operation is "Commando Vault."

According to the Seventh Air Force, the average rate of use of the Daisy Cutters in South Vietnam has been one to two per week in recent months. (We were made aware of five drops during a one-week period in mid-August.) Although the total number of drops to date is classified information, an official spokesman for the U.S. Military Assistance Command in Vietnam (MACV) informed me that it is

well in excess of 100. One press report claims that 160 drops occurred prior to June of 1970 (*Los Angeles Times*, June 1, 1970, p. 20). Most of the drops in South Vietnam have occurred in the northern half of the country and in the delta region to the south (Military Regions I, II, and IV). Information on the drops in Cambodia and Laos was not made available to us.

In the briefing we received on the Commando Vault operations, an official spokesman for the Seventh Air Force stressed and restressed that use of the Daisy Cutters was restricted to the creation of landing zones and that they were nothing more than "explosive bulldozers." He went into some detail on how the local populace is always alerted prior to a drop. On the other hand, we learned from another local Air Force source that exceedingly strict security is always maintained before a drop to avoid alerting the enemy; the flight crew does not even receive the target location or drop time until just before takeoff.

The Daisy Cutter is officially designated as a general-purpose bomb and has been used in a number of ways in Indochina beyond the creation of landing zones. One Air Force report explains that the bomb can be used for road interdiction by triggering landslides. In the Hanoi press this past spring (in an otherwise unconfirmed report) there is a description of the obliteration of an entire hamlet in Laos by this means. We also learned from three independent sources (two military and one embassy) that the Daisy Cutter has been and is being employed against enemy in suspected enemy troop concentrations. Moreover, in one of the Commando Vault missions we inspected from the air, the bomb had been dropped, according to our official military guide, onto a suspected enemy rocket emplacement. This mission had been carried out in June of this year in Quang Nam province nineteen miles southwest of Da Nang. The antipersonnel use of this bomb has also been reported in the press (for example, *New York Times*, Apr. 13, 1971, p. 1; Apr. 15, 1971, p. 5; Apr. 18, 1971, p. E2). Press reports describe one additional use for the bomb, that of removing the thick jungle canopy above suspected enemy storage areas (*New York Times*, Apr. 15, 1971, p. 5).

What is the environmental impact of a Daisy Cutter? Here I am chagrined to report that of the scores of Commando Vault missions, old and new, no site could be found by MACV in an area secure enough for us to visit. U.S. citizens are generally not aware that the National Liberation Front and its North Vietnamese allies control virtually all of the forest and other wild lands of South Vietnam. Moreover, we could find no one who had examined or even thought about these sites with ecology in mind, not even the MACV science advisor or his staff. Although the immediate overt impact is easy to surmise, the more subtle and long-term effects must await further study.

According to an official Seventh Air Force source, the blast of a Daisy Cutter is of such intensity that all terrestrial and arboreal wildlife (as well as any luckless humans) within a radius of approximately 3,280 feet are killed outright by the concussive shockwave. The lethal zone from one such bomb thus covers an area of about 776 acres. Beyond this circle of death, concussion injury diminishes to insignificance radially outward for a distance of another 1,640 feet or so. This larger area of both death and injury to wildlife thus encompasses about 1,746 acres per bomb. Assuming that the total number of bomb drops to date has been 150, the forest area totally eliminated by this means has been only about 300 acres. Of much greater concern, all the wildlife occupying 116,400 acres or more have been killed. The wildlife on again as much area have sustained injuries. The Daisy Cutter thus adds significantly to the already severe stress imposed by the war on Vietnam's wildlife.

With respect to the vegetation, my information on damage is less complete. The innermost circle of two acres is, of course, totally annihilated. (One press report claims that even the worms in the ground are killed in this zone [*Life* magazine, May 21, 1971, p. 41].) I suspect that damage to the flora beyond the central, cleared area becomes negligible within a modest distance, but actual extent of damage will require on-site investigation. Recolonization by plants in the central, cleared zone seems to be fairly rapid, at least in the delta region. An Air Force officer familiar with the delta told us that a Commando Vault landing zone blasted out in that region looks green from the air within several weeks; it often becomes unusable within several months because of the regrowth of brush. Past experience suggests that the upland clearings will be quickly invaded primarily by *Imperata* grass and/or a variety of low-growing, brushy bamboo species, all tenacious and worthless weeds.

The Daisy Cutter is, in the words of one military officer we met in Vietnam, "a super bomb with super punch." MACV has been using these bombs on a steady basis for more than a year and a half now, apparently with no mention of them in

the official daily, weekly, or monthly war news summaries. One senior Seventh Air Force officer explained to us, "they have such a devastating effect that we hate to give them much publicity."

The Commando Vault 7.5 ton bombs provide just one more means by which we casually rearrange the environment of Indochina with little if any concern about either the immediate or the long-term impact on the ecology of the area. I am painfully aware of how little in the way of biological data this report contains, but in providing the first detailed account of this new, indiscriminately wide-area weapon for the open literature, I hope that it will stimulate the necessary wildlife and other ecological studies as conditions permit.

ADDITIONAL REMARKS BY CONGRESSMAN GILBERT GUDE REGARDING S. RES. 281

OCTOBER 6, 1972.

Senator CLAIBORNE PELL,
Chairman, Oceans and International Environment Subcommittee of the Senate Foreign Relations Committee, Washington, D.C.

DEAR MR. CHAIRMAN: I subscribe to the general thrust of S. Res. 281. However, I would like to make a few qualifying remarks.

First, it should be recognized that some environmental warfare techniques inevitably will be developed in the course of legitimate civilian research. Thus article I (2) has a built-in vagueness when seeking "to apply to *any* research or experimentation *relating* to the development of any such activity as a weapon of war." It appears that any Treaty must rest more on political and moral commitments not to use or exploit new technologies than on an attempt to stop particular research and development programs.

Second, in view of the possibilities for unauthorized use of environmental warfare techniques, the use of such practices by non-signatory nations, or questions arising from the "non-military" use of environmental modification activity, I think it would be prudent to:

(a) Establish an international scientific monitoring and investigatory commission to determine the extent of any claimed environmental damage relating to military geophysical modification activities;

(b) Make provision for the body of data collected by the commission to be released, if desired by the principles, to the International Court of Justice for advisory or binding judgement on the merits of the case.

Third, I believe that the phrase "as a weapon of war" must be more clearly defined so that there is as precise a distinction as possible between legitimate civilian research and prohibited military research. We must be careful not to inhibit the justifiable and promising environmental research now being conducted by civilian scientists world-wide.

Fourth, I question whether S. Res. 281 adequately deals with the problem of isolated safety and defensive weather modification activities in quasi-military situations. For example, would S. Res. 281 prohibit the dispersal of fog at a military airport in order to land military or civilian aircraft? It is my belief that such techniques make sense and save lives but there is no allowance in the Treaty for such activities.

These remarks should not be construed as being overly critical of S. Res. 281. On the contrary, I applaud your leadership in this field and encourage you to press forward with determination.

With best regards,

GILBERT GUDE, *Member of Congress.*

[GEOPHYSICAL WARFARE]

HOW TO WRECK THE ENVIRONMENT*

(By Gordon J. F. MacDonald, United States)

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*From "Unless Peace Comes," Nigel Calder, Ed., The Viking Press, New York City, 1968.

fessional interests are further extended by his participation in national science policy-making. He is a member of President Johnson's Science Advisory Committee.

Among future means of obtaining national objectives by force, one possibility hinges on man's ability to control and manipulate the environment of his planet. When achieved, this power over his environment will provide man with a new force capable of doing great and indiscriminate damage. Our present primitive understanding of deliberate environmental change makes it difficult to imagine a world in which geophysical warfare is practiced. Such a world might be one in which nuclear weapons were effectively banned and the weapons of mass destruction were those of environmental catastrophe. Alternatively, I can envisage a world of nuclear stability resulting from parity in such weapons, rendered unstable by the development by one nation of an advanced technology capable of modifying the earth's environment. Or geophysical weapons may be part of each nation's armory. As I will argue, these weapons are peculiarly suited for covert or secret wars.

Science-fiction literature contains many suggestions of how wars would progress if man indeed possessed the ability to change weather, climate, or ocean currents. Many of these fictional suggestions, and other more serious discussions, fail to take into account the limitations of nature. Jules Verne gave a detailed discussion of displacing the earth's polar caps, thus making the world's climatic zones more equitable (*Les Voyages Extraordinaires; Sans Dessus Dessous*, Metzel, 1889). Verne's proposal was to eliminate the twenty-three-degree tilt in the earth's axis, putting it at right angles to the sun-earth plane. However, as Verne correctly pointed out in a subsequent discussion, the earth's equatorial bulge stabilizes our planet, and even the launching of a 180,000-ton projectile would produce a displacement of only one-tenth of a micron. Senator Estes Kefauver, Vice-Presidential candidate in the 1956 American election, rediscovered Verne's original proposal and was seriously concerned with the tipping of the earth's axis. He reported that the earth's axis could, as the result of an H-bomb explosion, be displaced by ten degrees. Either Senator Kefauver or his scientific advisers neglected the stabilizing influence of the earth's bulge. The maximum displacement that can be expected from the explosion of a one-hundred-megaton H-weapon is less than one micron, as Walter Munk and I pointed out in our book, *Rotation of the Earth* (Cambridge University Press, New York, 1960).

Substantial progress within the environmental sciences is slowly overcoming the gap between fact and fiction regarding manipulations of the earth's physical environment. As these manipulations become possible, history shows that attempts may be made to use them in support of national ambitions. To consider the consequences of environmental modification in struggles among nations, we need to consider the present state of the subject and how postulated developments in the field could lead, ten to fifty years from now, to weapons systems that would use nature in new and perhaps unexpected ways.

The key to geophysical warfare is the identification of the environmental instabilities to which the addition of a small amount of energy would release vastly greater amounts of energy. Environmental instability is a situation in which nature has stored energy in some part of the earth or its surroundings far in excess of that which is usual. To trigger this instability the required energy might be introduced violently by explosions or gently by small bits of material able to induce rapid changes by acting as catalysts or nucleating agents. The mechanism for energy storage might be the accumulation of strain over hundreds of millions of years in the solid earth, or the supercooling of water vapor in the atmosphere by updrafts taking place over a few tens of minutes. Effects of releasing this energy could be worldwide, as in the case of altering climate, or regional, as in the case of locally excited earthquakes or enhanced precipitation.

WEATHER MODIFICATION

The earth's atmosphere is an envelope of air that rotates, for the most part, at the same speed as the underlying continents and oceans. The relative motion between the atmosphere and the earth arises from sources and sinks of energy that vary in location and strength but which have, as their ultimate source, the sun's radiation. The quantities of energy involved in weather systems exceed by a substantial margin the quantity of energy under man's direct control. For instance, the typical amount of energy expended in a single tornado funnel is equivalent to about fifty kilotons of explosives; a single thunderstorm tower exchanges about ten times this much energy during its lifetime; an Atlantic hurricane of moderate size may draw from the sea more than 1000 megatons of energy. These vast quantities of energy make it unlikely that brute-force techniques will lead to sensible weather

modification. Results could be achieved, however, by working on the instabilities in the atmosphere.

We are now beginning to understand several kinds of instabilities in the atmosphere. Supercooled water droplets in cold clouds are unstable, but they remain liquid for substantial periods of time unless supplied with nuclei on which they can freeze. Conversion of water droplets to ice through the introduction of artificial nuclei can provide a local source of energy. This released heat can cause rising air currents, which in turn lead to further formation of supercooled water. This process may lead to rainfall at the ground greater than that which would have been produced without the artificial nucleation. A second instability may arise, in which water vapor condenses into water, again affecting the distribution of sensible energy. On a larger scale, there is the so-called baroclinic instability of atmospheric waves that girdle the planet. Through the imbalance of heat between equator and pole, energy in this instability is stored, to be released in the creation of large cyclonic storms in the temperate zones. There are other, less well understood instabilities capable of affecting climate; I shall return to them later.

What is the present situation with respect to weather modification and what might be reasonably expected in the future? Experiments over the past eighteen years have demonstrated unequivocally that clouds composed of supercooled water droplets can be transformed into ice-crystal clouds by seeding them with silver iodide, "dry ice" (frozen carbon dioxide), and other suitable chemical agents. This discovery has been applied operationally in the clearance of airports covered by supercooled ground fog. No analogous technique has yet evolved for clearing warm fog, although several promising leads are now being investigated. In the case of warm fog, the atmospheric instability is that water vapor distributed in small drops contains more surface energy than the same water distributed in large drops. The trick for clearance of this warm fog will be to discover some way of getting the small drops to organize themselves into larger ones and then fall to the ground.

There is increasing, though inconclusive, evidence that rainfall from some types of clouds and storm systems in temperate regions can be increased by ten to fifteen per cent by seeding. Somewhat more controversial evidence indicates that precipitation can be increased from tropical cumulus by techniques similar to those employed in temperate regions. Preliminary experiments on hurricanes have the aim of dissipating the clouds surrounding the eye of the storm in order to spread the energy of the hurricane and reduce its force. The results are controversial but indicate that seeding can, in certain circumstances, lead to a marked growth in the seeded cloud. This possiblity may have merit in hurricane modification, but experimentation has not yet resulted in a definitive statement.

Regarding the suppression of lightning, there is mixed but largely promising evidence that the frequency of clould-to-ground strokes can be reduced by the introduction of "chaff" strips of metallic foil of the kind used for creating spurious echoes in enemy radars.

In looking to the future, it is quite clear that substantial advances will be made in all of these areas of weather modification. Today, both military and civilian air transport benefit from progress in the clearance of ground fog. Further progress in the technology of introducing the seeding agent into the fog makes it likely that this type of fog dispersal will become routine. In a sense, fog clearing is the first military application of deliberate manipulation of weather, but it is, of course, very limited.

Large field programs are being undertaken in the United States to explore further the possibility of enhancing precipitation, particularly in the western and northeastern states. On the high ground of the western states, snow from winter storms provides much of the country's moisture. Investigations are under way to see if seeding can lead to an increased snowpack and thus enhance the water resources. Intense interest in this form of weather modification, coupled with an increased investigation of the physics of clouds, is likely to lead to effective cloud modification within the nest five to fifteen years. At present the effects are measured only statistically, and too little has been done in cloud observation before and after seeding in the way of precisely pinpointing which clouds are most likely to be affected.

As far as military applications are concerned, I conjecture that precipitation enhancement would have a limited value in classical tactical situations, and then only in the future when controls are more thoroughly understood. One could, for example, imagine field commanders calling for local enhancement of precipitation to cover or impede various ground operations. An alternative use of cloud seeding might be applied strategically. We are presently uncertain about the effect of

seeding on precipitation down wind from the seeded clouds. Preliminary analysis suggests that there is no effect 200-300 miles down wind, but that continued seeding over a long stretch of dry land clearly could remove sufficient moisture to prevent rain 1000 miles down wind. This extended effect leads to the possibility of covertly removing moisture from the atmosphere so that a nation dependent on water vapor crossing a competitor country could be subjected to years of drought. The operation could be concealed by the statistical irregularity of the atmosphere. A nation possessing superior technology in environmental manipulation could damage an adversary without revealing its intent.

Modification of storms, too, could have major strategic implications. As I have mentioned, preliminary experiments have been carried out on the seeding of hurricanes. The dynamics of hurricanes and the mechanism by which energy is transferred from the ocean into the atmosphere supporting the hurricane are poorly understood. Yet various schemes for both dissipation and steering can be imagined. Although hurricanes originate in tropical regions, they can travel into temperate latitudes, as the residents of New England know only too well. A controlled hurricane could be used as a weapon to terrorize opponents over substantial parts of the populated world.

It is generally supposed that a hurricane draws most of its energy from the sea over which it passes. The necessary process of heat transfer depends on wave action that permits the air to come in contact with a volume of water. This interaction between the air and water also stirs the upper layers of the atmosphere and permits the hurricane to draw on a substantially larger reservoir of heat than just the warm surface water. There may be ways, using monomolecular films of materials like those developed for covering reservoirs to reduce evaporation, for decreasing the local interaction between sea and air and thus preventing the ocean from providing energy to the hurricane in an accelerated fashion. Such a procedure, coupled with selective seeding, might provide hurricane guidance mechanisms. At present we are a long way from having the basic data and understanding necessary to carry out such experiments; nevertheless, the long-term possibility of developing and applying such techniques under the cover of nature's irregularities presents a disquieting prospect.

CLIMATE MODIFICATION

In considering whether or not climate modification is possible, it is useful to examine climate variations under natural conditions. Firm geological evidence exists of a long sequence of Ice Ages, in the relatively recent past, which shows that the world's climate has been in a state of slow evolution. There is also good geological, archaeological, and historical evidence for a pattern of smaller, more rapid fluctuations superimposed on the slow evolutionary change. For example, in Europe the climate of the early period following the last Ice Age was continental, with hot summers and cold winters. In the sixth millennium B.C., there was a change to a warm humid climate with a mean temperature of five degrees Fahrenheit higher than at present and a heavy rainfall that caused considerable growth of peat. This period, known as a climatic optimum, was accentuated in Scandinavia by a land subsidence that permitted a greater influx of warm Atlantic water into the large Baltic Sea.

The climatic optimum was peculiar. While on the whole there was a very gradual decrease of rainfall, the decrease was interrupted by long droughts during which the surface peat dried. This fluctuation occurred several times, the main dry periods being from 2000 to 1900, 1200 to 1000, and 700 to 500 B.C. The last, a dry heat wave lasting approximately 200 years, was the best developed. The drought, though not sufficiently intense to interrupt the steady development of forests, did cause extensive migrations of peoples from drier to wetter regions.

A change to colder and wetter conditions occurred in Europe about 500 B.C. and was by far the greatest and most abrupt alteration in climate since the end of the last Ice Age. It had a catastrophic effect on the early civilization of Europe: large areas of forest were killed by the rapid growth of peat, and the levels of the Alpine lakes rose suddenly, flooding many of the lake settlements. This climatic change did not last long; by the beginning of the Christian era, conditions did not differ greatly from current ones. Since then climatic variations have continued to occur, and although none has been as dramatic as that of 500 B.C., a perturbation known as the little ice age of the seventeenth century is a recent noteworthy example. The cause of these historical changes in climate remains shrouded in mystery. The rapid changes of climate in the past suggest to many that there exist instabilities affecting the balance of solar radiation.

Indeed, climate is primarily determined by the balance between the incoming short wave from the sun (principally light) and the loss of outgoing long-wave radiation (principally heat).

Three factors dominate the balance: the energy of the sun, the surface character of terrestrial regions (water, ice, vegetation, desert, etc.), and the transparency of the earth's atmosphere to different forms of radiated energy. In the last connection, the effect of clouds in making cool days and relatively warm nights is a matter of familiar experience. But clouds are a manifestation rather than an original determinant of weather and climate; of more fundamental significance is the effect of gases in the atmosphere, which absorb much of the radiation in transit from the sun to the earth or from the earth into space. Intense X-rays and ultraviolet from the sun, together with high-energy atomic particles, are arrested in the upper atmosphere. Only the narrow band of visible light and some short radio waves traverse the atmosphere without serious interruption.

There has been much controversy in recent years about conjectured over-all effects on the world's climate of emissions of carbon dioxide to the atmosphere from furnaces and engines burning fossil fuels, and some about possible influences of the exhaust from large rockets on the transparency of the upper atmosphere. Carbon dioxide placed in the atmosphere since the start of the industrial revolution has produced an increase in the average temperature of the lower atmosphere of a few tenths of a degree Fahrenheit. The water vapor that may be introduced into the stratosphere by the supersonic transport may also result in a similar temperature rise. In principle it would be feasible to introduce material into the upper atmosphere that would absorb either incoming light (thereby cooling the surface) or outgoing heat (thereby warming the surface). In practice, in the rarefied and windswept upper atmosphere, the material would disperse rather quickly, so that military use of such a technique would probably rely upon global rather than local effects. Moreover, molecular material will tend to decompose, and even elemental materials will eventually be lost by diffusion into space or precipitation to the surface. At intermediate levels, in the stratosphere, materials may tend to accumulate, though the mixing time for this part of the atmosphere is certainly less than ten years and may be a few months. If a nation's meteorologists calculated that a general warming or cooling of the earth was in their national interest, improving their climate while worsening others, the temptation to release materials from high-altitude rockets might exist. At present we know took little about the paradoxical effects of warming and cooling, however, to tell what the outcome might be.

More sudden, perhaps much briefer but nevertheless disastrous, effects are predictable if chemical or physical means were developed for attacking one of the natural constituents of the atmosphere—ozone. A low concentration of ozone (O_3, a rare molecular form of oxygen) in a layer between fifteen and fifty kilometers altitude has the utmost significance for life on land. It is responsible for absorbing the greater part of the ultraviolet from the sun. In mild doses, this radiation causes sunburn; if the full force of it were experienced at the surface, it would be fatal to all life—including farm crops and herds—that could not take shelter. The ozone is replenished daily, but a temporary "hole" in the ozone layer over a target area might be created by physical or chemical action. For example, ultraviolet at 250 millimicrons wave length decomposes ozone molecules, and ozone reacts readily with a wide range of materials.

At present, we can only tentatively speculate about modifying the short-wave radiation at its source, the sun. We have discovered major instabilities on the sun's surface that might be manipulated many years hence. In a solar flare, for example, 10^{10} megatons of energy are stored in distorted magnetic fields. With advanced techniques of launching rockets and setting off large explosions, we may sometime in the future learn to trigger these instabilities. For the near future, however, modification will not be in the short-wave incoming radiation but in the long-wave outgoing radiation.

The usual schemes for modifying climate involve the manipulation of large ice fields. The persistence of these large ice fields is due to the cooling effects of the ice itself, both in reflecting (rather than absorbing) incoming shortwave radiation and in radiating heat at a higher rate than the usual ground cover. A commonly suggested means of climate modification involves thin layers of colored material spread on an icy surface, thus inhibiting both the reflection and radiation processes, melting the ice, and thereby altering the climate. Such a procedure presents obvious technical and logistic difficulties. For example, if one wished to create a surface coating of as little as one micron thickness to cover a square 1000 kilometers in size, the total material for this extremely thin coating would weigh a million tons or more, depending upon its density. So the proposals to dust from the air

some of the globe's extended ice sheets are unrealistic and reflect a brute-force technique, taking no advantage of instabilities within the environment.

Although it may be technologically difficult to change an ice cap's surface character, and thus its thermal properties, it may be possible to move the ice, taking into account the gravitational instability of ice caps. The gravitational potential energy of water as a thick, high ice cap is much greater than it would be at sea level. This fact makes it possible, at least in principle, to devise schemes for bringing about a redistribution in the ice. Indeed, A. T. Wilson has proposed a cyclical theory for the Ice Ages, based on this instability.

The main points of Wilson's theory are as follows:

1. Antarctica is covered by an ice sheet several kilometers thick. Pressure at the bottom of the ice is great enough to keep the ice at or near its melting point; water is an unusual material in that a pressure increase lowers rather than raises its melting point. An increase in thickness of the ice sheet could result in melting at the bottom. The resulting ice-water mixture along the sole of the glacier would permit flow by a process of freezing and melting—a flow process much more effective than ordinary plastic flow.

2. If such an instability occurs, the ice sheet will flow out onto the surrounding sea, and a large ice shelf will be formed between Antarctica and the ocean around it. As a consequence, short-wave solar radiation will be reflected, and there will be enhanced loss of heat by radiation at the long wave lengths, causing cooling and the inducement of world-wide glaciation.

3. Once the ice shelf is in the ocean, it will begin to melt and eventually will be removed. The ice remaining on land will be much thinner than before. As the reflectivity of the southern hemisphere decreases with the melting of the Antarctic ice cap, the global climate will grow warmer again, corresponding to the start of an interglacial period. The ice cap will slowly form again.

Commenting on Wilson's theory, J. T. Hollin has noted the possibility of a catastrophic surge or advance of the ice sheet, such as has been recorded from small glaciers on numerous occasions. The largest surge yet reported is probably that of the ice cap in Spitsbergen, which advanced up to twenty-one kilometers on a front of thirty kilometers sometime between 1935 and 1938. There are also reports of glacial advances at speeds up to one hundred meters per day. Hollin speculates that, once the bottom-melting phase of a gravitationally unstable ice cap is reached it will move quickly. In addition to trapped geothermal heat melting the ice at the bottom, there are additional contributions from frictional heat generated as the glacier scrapes along the solid ground.

If the speculative theory of Wilson is correct (and there are many attractive features to it), then a mechanism does exist for catastrophically altering the earth's climate. The release of thermal energy, perhaps through nuclear explosions along the base of an ice sheet, could initiate outward sliding of the ice sheet which would then be sustained by gravitational energy. One megaton of energy is sufficient to melt about 100 million tons of ice. One hundred megatons of energy would convert 0.1 cm. of ice into a thin layer of water covering the entire Antarctic ice cap. Lesser amounts of energy suitably placed could undoubtedly initiate the outward flow of the ice.

What would be the consequences of such an operation? The immediate effect of this vast quantity of ice surging into the water, if velocities of one hundred meters per day are appropriate, would be to create massive tsunamis (tidal waves) that would completely wreck coastal regions even in the Northern Hemisphere. There would then follow marked changes in climate brought about by the suddenly changed reflectivity of the earth. At a rate of one hundred meters per day, the center of the ice sheet would reach the land's edge in forty years.

Who would stand to benefit from such application? The logical candidate would be a landlocked equatorial country. An extended glacial period would insure near-Arctic conditions over much of the temperate zone, but temperate climate with abundant rainfall would be the rule in the present tropical regions.

FUTURE OF WEATHER AND CLIMATE MODIFICATION

The foregoing perhaps represents a more positive view of weather and climate modification than that held by many earth scientists. I believe this view is justified as it is based on three scientific and technological advances. First, understanding of basic meteorology has advanced to such an extent that mathematical models of the atmosphere here have been developed incorporating the most important elements. Physical processes in clouds, in turbulent exchanges at the surface, and

in transmission of radiation through the atmosphere are no longer as mysterious as they once were. The volumes simulated by the models range from the size of a single cloud to the entire atmosphere; these models are no longer primitive representations.

Secondly, the advent of high-speed computers enables atmospheric models to be studied in greater detail. These computers have a peculiar importance to weather modification, since they will enable scientists to carry out extended experiments to test whether or not various schemes for manipulating the atmosphere are indeed possible and what the outcome should be.

The third advance lending support to expectations for weather and climate modification is the new array of instruments developed to observe and detect changes in the atmosphere. The most dramatic and perhaps the most powerful is the meteorological satellite, which provides a platform whence the atmosphere can be observed, not only in geographically inaccessible regions, but also with entirely new physical measurements. For example, meteorological satellites of the future will permit the determination of humidity, temperature, and pressure as averaged over substantial volumes of the atmosphere, providing quantities that are needed to develop the mathematical models. Sophisticated surface instrumentation, for observing detailed processes within smaller parts of the atmosphere, provides us with far more powerful tools with which to look at clouds and at the interaction of the atmosphere with its boundaries than those which were available ten or twenty years ago.

EARTHQUAKE MODIFICATION

What causes earthquakes? Over geological time, the irregular distribution of heat-producing radioactive elements in the rock layers gives rise to subsurface temperature differences between various parts of the earth. In the continents, granites and similar rocks have concentrated radioactive elements near the surface; no similar concentration has taken place in the suboceanic regions, which may as a result be more than one hundred degrees centigrade cooler than the corresponding subcontinental regions. Such variations in temperature along a horizontal line, due to the differences in the vertical distribution of heat-producing elements, give rise to large thermal stresses, causing strain analogous to that which cracks a glass tumbler filled with hot water. The strain tends to be greatest in regions of abrupt temperature change along a horizontal line through the earth's crust. The strain may be partially relieved by the slow convective flow of material in the deep earth which is thought by some geophysicists to push continents about. But the strain can also be relieved by sharp fractures or by movements along previous faults in rocks near the surface. Movement along a fault radiates energy outward, which results in an earthquake. Each year approximately 200 megatons of strain energy is released in this fashion, the largest earthquakes corresponding to energy of the order of 100 megatons. The energy released depends on the volume of material affected. The largest earthquakes take place along faults having a linear dimension of 1000 kilometers, whereas smaller ones take place along faults of one kilometer or less.

Major earthquakes tend to be located along two main belts. One belt, along which about eighty-five percent of the total energy is released, passes around the Pacific and affects countries whose coastlines border this ocean, for example Japan and the west coast of North America. The second belt passes through the Mediterranean regions eastward through Asia and joins the first belt in Indonesia. Along these two belts, large earthquakes occur with varying frequencies. In California a large earthquake might be expected once every fifty to one hundred years, while Chile might expect such a disturbance once every ten to twenty years. Sometimes major earthquakes have occurred in regions ordinarily thought of as being free from risk. For example, the New Madrid earthquake of 1811–1812 devastated a large area of central North America but had only slight cultural effects because of the area's sparse population.

Today, our detailed understanding of the mechanism that causes an earthquake and of how the related instabilities can be triggered is limited. Only within the last few years have serious discussions of earthquake prediction begun, whereas moderately reliable weather forecasts have been available for about the last thirty to fifty years. Currently, substantial effort is being made, primarily by Japan and the United States, to develop techniques for forecasting earthquakes. These techniques are based to a large extent on the determination of changing strain conditions of materials in the rocks surrounding recognized fault zones. Of possible value is the observation that before an earthquake the accumulating strain accelerates.

Control of earthquakes is a prospect even more distant than that of forecasting, although two techniques have been suggested through recent experience.

1. In the course of the underground testing of nuclear weapons at the Nevada test site, it was observed that an explosion apparently released local strain in the earth. The hypothesis is that the swift build-up of strain due to the sudden release of energy in an explosion discharges strain energy over a large volume of material.

2. Another method of releasing strain energy has appeared from pumping of underground water in the vicinity of Denver, Colorado, which has led to a series of small earthquakes. The hypothesis here is that underground water has provided local lubrication permitting adjacent blocks to slip by one another.

The use as a weapon system of the strain energy instability within the solid earth requires an effective triggering mechanism. A scheme for pumping water seems clumsy and easily detectable. On the other hand, if the strain pattern in the crust can be accurately determined, the phased or timed release of energy from smaller faults, designed to trigger a large fault at some distance, could be contemplated. This timed release could be activated through small explosions and thus it might be possible to use this release of energy stored in small faults at some distance from a major fault to trigger that major fault. For example, the San Andreas fault zone, passing near Los Angeles and San Francisco, is part of the great earthquake belt surrounding the Pacific. Good knowledge of the strain within this belt might permit the setting off of the San Andreas zone by timed explosions in the China Sea and Philippine Sea. In contrast with certain meteorological operations, it would seem rather unlikely that such an attack could be carried out covertly under the guise of natural earthquakes.

MODIFICATION OF OCEANS

We are still in the very early stages of developing the theory and techniques for predicting the state of the oceans. In the past two decades methods have been devised for the prediction of surface waves and surface wind distribution. A warning system for the tsunamis (tidal waves) produced by earthquakes has also been developed.

Certain currents within the oceans have been identified, but we do not yet know what the variable components are; that is, what the weather within the ocean is. Thus we have not been able to identify any instabilities within the oceanic circulation that might be easily manipulated. As in the case of the solid earth, we can only speculate tentatively about how oceanic processes might be controlled.

One instability offering potential as a future weapon system is that associated with tsunamis. These frequently originate from the slumping into the deep ocean of loosely consolidated sediments and rocks perched on the continental shelf. Movement of these sediments can trigger the release of vast quantities of gravitational energy, part of which is converted in the motion of the tsunami. For example, if, along a 1000-kilometer edge of a continental shelf, a block 100 meters deep and ten kilometers wide were dropped a distance of 100 meters, about 100 megatons of energy would be released. This release would be catastrophic to any coastal nation. How could it be achieved? A series of phased explosions, perhaps setting off natural earthquakes, would be a most effective way. I could even speculate on planning a guided tidal wave, where guidance is achieved by correctly shaping the source which releases energy.

BRAIN WAVES AROUND THE WORLD?

At heights of forty to fifty kilometers above the earth's surface substantial numbers of charged particles are found which make this part of the atmosphere, the ionosphere, a good conductor of electricity. The rocks and oceans are also more conducting than the lower atmosphere. Thus, we live in an insulating atmosphere between two spherical conducting shells or, as the radio engineer would put it, in an earth-ionosphere cavity, or wave guide. Radio waves striking either conducting shell tend to be reflected back into the cavity, and this phenomenon is what makes conventional long-distance radio communication possible. Only recently, however, has there been any interest in natural electrical resonances within the earth-ionosphere wave guide. Like any such cavity, the earth ionosphere wave guide will tend to sustain radio oscillation at certain frequencies in preference to others. These resonant frequencies are primarily determined by the size of the earth and the speed of light, but the properties of the ionosphere modify them to a certain extent. The lowest resonances begin at about eight cycles per second, far below the frequencies ordinarily used for radio communication.

Because of their long wave length and small field strength, they are difficult to detect. Moreover, they die down quickly, within one sixteenth of a second or so; in engineering terms, the cavity has a short-time constant.

The natural resonant oscillations are excited by lightning strokes, cloud-to-ground strokes being a much more efficient source than horizontal cloud-to-cloud discharges. On the average, about one hundred lightning strokes occur each second (primarily concentrated in the equatorial regions), so that normally about six lightning flashes are available to introduce energy before a particular oscillation dies down. A typical oscillation's field strength is of the order of 0.3 millivolts per meter.

The power of the oscillations varies geographically. For example, for a source located on the equator in Brazil the maximum intensity of the oscillation is near the source and at the opposite side of the earth (around Indonesia). The intensity is lower in intermediate regions and toward the poles.

One can imagine several ways in which to increase the intensity of such electrical oscillations. The number of lightning strokes per second could be enhanced by artificially increasing their original number. Substantial progress has been made in the understanding of the physics of lightning and of how it might be controlled. The natural oscillations are excited by randomly occurring strokes. The excitation of timed strokes would enhance the efficiency with which energy is injected into an oscillation. Furthermore, the time constant of the oscillation would be doubled by a fourfold increase in the electrical conductivity of the ionosphere, so that any scheme for enhancing that conductivity (for example, by injecting readily ionized vapor) lowers the energy losses and lengthens the time constant, which would permit a greater number of phased lightning strokes before the decay of an oscillation.

The enhanced low-frequency electrical oscillations in the earth-ionosphere cavity relate to possible weapons systems through a little understood aspect of brain physiology. Electrical activity in the brain is concentrated at certain frequencies, some of it extremely slow, a little around five cycles per second, and very conspicuous activity (the so-called alpha rhythm) around ten cycles per second. Some experiments have been done in the use of a flickering light to pull the brain's alpha rhythm into unnatural synchrony with it; the visual stimulation leads to electrical stimulation. There has also been work on direct electrical driving of the brain. In experiments discussed by Norbert Wiener, a sheet of tin is suspended from the ceiling and connected to a generator working at ten cycles per second.

With large field strengths of one or two volts per centimeter oscillating at the alpha-rhythm frequency, decidedly unpleasant sensations are noted by human subjects.

The Brain Research Institute of the University of California is investigating the effect of weak oscillating fields on human behavior. The field strengths in these experiments are of the order of a few hundredths of a volt per centimeter. Subjects show small but measurable degradation in performance when exposed to oscillating fields for periods of up to fifteen minutes.

The field strengths in these experiments are still much stronger, by a factor of about 1000, than the observed natural oscillations in the earth-ionosphere cavity. However, as previously noted, the intensity of the natural fluctuations could be increased substantially and in principle could be maintained for a long time, as tropical thunderstorms are always available for manipulation. The proper geographical location of the source of lighting, coupled with accurately timed, artificially excited strokes, could lead to a pattern of oscillations that produced relatively high power levels over certain regions of the earth and substantially lower levels over other regions. In this way, one could develop a system that would seriously impair brain performance in very large populations in selected regions over an extended period.

The scheme I have susggested is admittedly far-fetched, but I have used it to indicate the rather subtle connections between variations in man's environmental conditions and his behavior. Perturbation of the environment can produce changes in behavior patterns. Since our understanding of both behavioral and environmental manipulation is rudimentary, schemes of behavioral alteration on the surface seem unrealistic. No matter how deeply disturbing the thought of using the environment to manipulate behavior for national advantage is to some, the technology permitting such use will very probably develop within the next few decades.

Deficiencies both in the basic understanding of the physical processes in the environment and in the technology of environmental change make it highly unlikely that environmental modification will be an attractive weapon system in any direct military confrontation in the near future. Man already possesses highly effective tools for destruction. Eventually, however, means other than open warfare may be used to secure national advantage. As economic competition among many advanced nations heightens, it may be to a country's advantage to ensure a peaceful natural environment for itself and a disturbed environment for its competitors. Operations producing such conditions might be carried out covertly, since nature's great irregularity permits storms, floods, droughts, earthquakes, and tidal waves to be viewed as unusual but not unexpected. Such a "secret war" need never be declared or even known by the affected populations. It could go on for years with only the security forces involved being aware of it. The years of drought and storm would be attributed to unkindly nature, and only after a nation was thoroughly drained would an armed takeover be attempted.

In addition to their covert nature, a feature common to several modification schemes is their ability to affect the earth as a whole. The environment knows no political boundaries; it is independent of the institutions based on geography, and the effects of modification can be projected from any one point to any other on the earth. Because environmental modification may be a dominant feature of future world decades, there is concern that this incipient technology is in total conflict with many of the traditional geographical and political units and concepts.

Political, legal, economic, and sociological consequences of deliberate environmental modification, even for peaceful purposes, will be of such complexity that perhaps all our present involvements in nuclear affairs will seem simple. Our understanding of basic environmental science and technology is primitive, but still more primitive are our notions of the proper political forms and procedures to deal with the consequences of modification. All experience shows that less significant technological changes than environmental control finally transform political and social relationships. Experience also shows that these transformations are not necessarily predictable, and that guesses we might make now, based on precedent, are likely to be quite wrong. It would seem, however, that these nonscientific, nontechnological problems are of such magnitude that they deserve consideration by serious students throughout the world if society is to live comfortably in a controlled environment.

Author's note: In the section on weather modification I have drawn heavily on *Weather and Climate Modification* (National Academy of Sciences, National Research Council, Washington, 1966). A. T. Wilson's paper on "Origin of Ice Ages" appeared in *Nature*, vol. 201, pp. 147–49 (1964), and J. T. Hollin's comments in vol. 208, pp. 12–16 (1965). Release of tectonic strain by underground nuclear explosion was reported by F. Press and C. Archambeau in *Journal of Geophysical Research*, vol. 67, pp. 337–43 (1962), and man-made earthquakes in Denver by D. Evans in *Geotimes*, vol. 10, pp. 11–17. I am grateful to J. Homer and W. Ross Adey, of the Brain Research Institute of the University of California at Los Angeles, for information on the experimental investigation of the influence of magnetic fields on human behavior.

Environmental Warfare and Ecocide—Facts, Appraisal, and Proposals (Revised Version)

(By Richard A. Falk, Princeton University)

I

In Indochina during the past decade we have the first modern instance in which the environment has been selected as a "military" target appropriate for comprehensive and systematic destruction. Such an occurrence does not merely reflect the depravity of the high-technology sensibilities of the war-planners. It carries out the demonic logic of counterinsurgency warfare, especially when the insurgent threat is both formidable and set in a tropical locale. Recourse to deliberate forms of environmental warfare is part of the wider military conviction that the only way to defeat the insurgent is to deny him the cover, the food, and the life-support of the countryside.

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Under such conditions bombers and artillery seek to disrupt all activity, and insurgent forces find it more difficult to mass for effective attack. Such policies have led in Indochina to the destruction of vast tracts of forest land and to so-called "crop-denial programs." The U.S. Government has altered tactics in recent years, shifting from chemical herbicides to Rome Plows as the principal means to strip away the protective cover of the natural landscape, but the basic rationale of separating the people from their land and its life-support characteristics persists. Such policies must be coupled with the more familiar tenets of counterinsurgency doctrine which seek to dry up the sea of civilians in which the insurgent fish attempt to swim. This drying up process is translated militarily into making the countryside unfit for civilian habitation. To turn Indochina into a sea of fire and compel peasants to flee their ancestral homes was consciously embodied in a series of war policies including "free-fire zones," "search and destroy" operations, and the various efforts to move villagers forcibly into secure areas. Therefore, it is important to understand the extent to which environmental warfare is linked to the overall tactics of high-technology counterinsurgency warfare, and extends the indiscriminateness of warfare carried on against people to the land itself. Just as counterinsurgency warfare tends toward genocide with respect to the people, so it tends toward ecocide with respect to the environment.

It may be more than coincidental that at the historical moment when we are in the process of discovering the extent to which man's normal activities are destroying the ecological basis of life on the planet that we should also be confronted by this extraordinary enterprise in Indochina of deliberate environmental destruction. These conscious and unconscious tendencies need to be linked in any adequate formulation of the world order challenge confronting mankind. It is also worth noting that so far, at least, the target area of environmental warfare is the Third World, a sector of world society that has largely disavowed the relevance of the ecological agenda to its schedule of priorities. Environmental warfare is a dramatic reminder of the extent to which the planet as a whole must mobilize a response to the ecological challenge to sustain life on earth and beat back reversions to barbarism emanating from the "advanced" regions and applied to those that are relatively "backward." It is a form of dangerous provincialism for the countries of Asia and Africa to call for "benign neglect" when it comes to this subject-matter; perhaps the relevance of ecological issues can be grasped more clearly by Third World leaders and peoples in relation to environmental warfare.

II

On a more technical level there are several issues of related concern that need to be considered. First of all, it seems important to assess the extent to which patterns of environmental warfare violate existing criteria of legal judgment. Secondly, there is a need to promote the development of new law that captures the uniqueness of recent developments and anticipates future dangers; in particular, the search for clear standards of legal prohibition directed explicitly toward environmental warfare might help shape future conduct. Many governments have been reluctant to protest against what the United States has been doing in Indochina and so have avoided a concern with environmental warfare. At this stage it is possible to formulate, at least, a series of public demands around which popular support needs to be rallied if governments and world institutions are going to join in the movement for rectifying action.

III

In considering the relevance of international law I wish to make several preliminary points that bear on more specific assessments:

(1) The connection between treaties and customary international law.

(2) The role of world community consensus in interpreting the requirements of international law.

(3) The importance of principles of customary international law for the interpretation of the legal status of disputed tactics of warfare.

(4) The importance of moral considerations in judging what is permissible behavior of governments and their officials.

(5) The significant distinction between the illegality of governmental conduct and the criminality of individual conduct (whether or not in the line of official duty).

1. The connection between treaties and customary international law

There has been a tendency by governments to confine the scope of the law of war to treaty law. Such confinement is improper. Even the US Army Field Manual 27–10 acknowledges that customary international law complements treaty rules. It is important to understand that customary norms exist and apply because of the degree to which modern weaponry and battlefield tactics have evolved since the time when the basic treaties were formulated at the turn of the century. The broad lawmaking treaties in 1907 bearing on the law of war were themselves specific embodiments of general principles of belligerent restraint as they related to war technology and tactics existing at that time. These customary principles, more than the treaty rules they gave rise to, remain the primary basis for giving legal substance to the law of war in the face of a drastically altered technological and military environment. New treaties would be desirable, because of their capacity to generate agreed interpretations of the specific implications of new weaponry and tactics in relation to the customary principles underlying the law of war. Such treaties could provide authoritative reading of limits on state behavior and would also be more likely to engender respect as contemporary government officials would have taken part in the reformulation process and renewed their commitments by participating in the treaty-making rituals of solemnity.[1]

But in the absence of a new round of Hague-type conferences the best ground that exists for legal judgment is to examine contested belligerent practices in light of the more general policies to which they gave expression. Customary principles of international law [see section (3) below] are of great importance in an effort to understand the legal status of the various dimensions of environmental warfare.

2. The role of world community consensus in interpreting the requirements of international law

The increasing number of actors, their diversity, and the complexity of international life make it more difficult to rely upon procedures based on *governmental consent* to develop either binding new interpretations of old rules or the generation of new rules of international law. In such a context a consensus of governments acting within the scope of formal procedures is increasingly viewed as capable of generating authoritative interpretations and standards. The most significant arena wherein these newer procedures of law-creation have been used is the General Assembly of the United Nations. The status of these resolutions remains controversial, especially among the more sovereignty-oriented governments, but I think the record of reliance on such resolutions in areas of arms control, space, and human rights creates a body of practice in support of the contention that these resolutions can, where intended by a large majority of governments, declare and create law.

It is true that the degree of authoritativeness and effectiveness of such lawmaking activity will depend on a number of factors including the strength and quality of consensus, the strength and quality of dissent, the specificity of demand, the willingness to implement conformity with prior legal and moral expectations. The basic point is that the General Assembly now possesses a quasi-legislative competence that needs to be seriously considered whenever it is relevant, especially when it sets forth a prevailing interpretation of the content of a previously agreed upon legal rule.

3. The importance of principles of customary international law for the interpretation of disputed tactics of warfare

Four principles of customary international law provide guidelines for the interpretation of any belligerent conduct not specifically covered by valid treaty rule:

I. *Principle of necessity.*—No tactic or weapon may be employed in war that inflicts superfluous suffering on its victims even if used in the pursuit of an otherwise reasonable military objective.

II. *Principle of humanity.*—No tactic or weapon may be employed in war that is inherently cruel and offends minimum and widely shared moral sensibilities.

[1] Such an argument is convincingly set forth in Abram Chayes, "An Inquiry into the Workings of Arms Control Agreements," Harvard Law Review, Vol. 85 (March 1972), pp. 905–969.

III. *Principle of proportionality.*—No weapon or tactic may be employed in war that inflicts death, injury, and destruction disproportionate to its contribution to the pursuit of lawful military objectives.

IV. *Principle of discrimination.*—No weapon or tactic may be employed in war that fails to discriminate between military and non-military targets and that is either inherently or in practice incapable of discriminating between combatants and noncombatants.

These four principles are general and are admittedly difficult to apply to the complexities of the battlefield. However, a rule of reason can be used to identify patterns (as distinct from instances) of clear violation, where the weapons and tactics are used in such a way as cannot be reasonably construed as compatible with these principles of overriding constraint. Such principles also reflect a minimum moral content that underlies the whole enterprise of a law of war, admitting its inevitable horror, but still striving for a mitigating framework of restraint.

Customary principles of international law are especially important in relation to the law of war because of its dynamic character. The underlying commitment of governments to restraint depends upon the interplay between good faith adherence to these four principles and the actualities of war. The famous DeMartens clause inserted in the Hague Conventions acknowledged this importance:

> Until a more complete code of the laws of war has been issued, the high contracting Parties deem it expedient to declare that, in cases not included in the Regulations adopted by them, the inhabitants and belligerents remain under the protection and the rule of the principles of the law of nations, as they result from the usages established among civilized peoples, from the laws of humanity, and the dictates of public conscience.

Widely ratified treaties such as the 1925 Geneva Protocol on Gas, Chemical, and Bacteriological Warfare may also attain the status of customary international law by virtue of a consensus among governments active in the world community—even if the consensus falls short of unanimity—and thereby bind non-parties. The reasoning here is analogous to that used in section (2) to discuss the potentially authoritative status of General Assembly Resolutions purporting to interpret a treaty. G. A. Resolution 2603A (XXIV), which extends the coverage of the Geneva Protocol to tear gas and herbicides, illustrates both an effort to make a binding interpretation of a treaty rule and to extend the coverage of the treaty to the entire community including nonparties. In the test of G. A. Resolution 2603A "the General Assembly . . . called for the strict observance by all States of the principles and objectives of the Geneva Protocol" and "Declares as contrary to the generally recognized rules of international law as embodied in the Geneva Protocol" the use of tear gas and chemical herbicides. The point here, which will be discussed later, is that the United States is bound by "the principles and objectives" of the Geneva Protocol, including the interpretation of its scope even though it has not ratified the treaty, In essence, such a conclusion reflects the view that an impartial third party—for instance, the International Court of Justice—would find that the United States is bound by the Geneva Protocol and by the interpretation of its scope affirmed by the overwhelming majority of governments. Such a prediction may be made either because the Resolution is itself law-proclaiming and authoritative or because it is indeed an accurate declaration of the proper meaning of the Geneva Protocol (and parallel norm in customary international law).

As a practical matter, U.S. ratification may still be important because much of the international law of war depends for effective application upon self-enforcement, especially when the actor is a major state not in conflict (and hence not deterred by) another major state. The United States would be much more likely to respect the Geneva Protocol, as generally, if it explicitly ratified the treaty, even though it remains the case that it is bound by its terms even prior to ratification.[2]

A final point has to do with the common contention that governments have generally used whatever weapons and tactics seemed to confer upon them a military advantage without according much, if any, heed to restraining principles of customary international law, or for that matter, of treaty law. There is even a common misunderstanding that a claim of military necessity overrides legal restraints. The agreed understanding of governments embodied in the law of war is that legal restraints have been formulated with due regard for military necessity, and that any further unilateral abridgements are violations. To say that the law

[2] Indeed, it could diminish the scope of its obligation by accompanying its ratification with either a reservation or a statement of understanding which maintained the option to use herbicides and riot control gasses.

of war is frequently violated is merely to affirm that governments are not very law-abiding in this area, and are indeed criminally disposed, especially where their vital interests are at stake.

Such a conclusion argues more for a different system of law enforcement—perhaps spearheaded by a law-minded citizenry—than for a suspension or negation of these international rules. Also, there is evidence, even bearing directly on the use of gas in war, to suggest that legal restraints were respected including by the United States, despite the fact that it has not been a party to the Geneva Protocol, and despite the prospect of some military advantage resulting from the use of gas in the Pacific island warfare against the Japanese during World War II.

4. The importance of moral factors in judging what is permissible behavior of governments and their officials

The law of war attempts to reconcile minimum morality with the practical realities of war. This reconciliation is best summarized in the four principles of customary international law. The moral sense of the community provides a legislative direction for the growth and understanding of international law.

In no area is it as appropriate as in relation to war to contend that "the law" does and should reflect that which ought to have been done or not done by governments and their representatives. Morality, in this sense, attempts to fill the legislative vacuum created by the institutional deficiencies of international society and adapt law to some extent to the rapidly changing realities of war. In this sense the growth of the international law of war may contain a greater element of retroactivity than in the more developed constitutional systems of domestic society, but the retroactivity exists only on a legalistic plane. The Nuremberg initiative provides our most dramatic illustration of a legislative spasm in international law that rested on the firmest grounds of shared morality, but aroused criticism from legalistically inclined observers.[3] The Indochina context, given the public outrage over the desecration of the land at a time of rising environmental consciousness, creates a target of opportunity comparable to Nuremberg. Surely it is no exaggeration to consider the forests and plantations treated by Agent Orange as an Auschwitz for environmental values, certainly not from the perspective of such a distinct environmental species as the mangrove tree or nipa palm. And just as the Genocide Convention came along to formalize part of what had already been condemned and punished at Nuremberg, so an Ecocide Convention could help carry forward into the future a legal condemnation of environmental warfare in Indochina.

5. The significant distinction between the illegality of governmental conduct and the criminality of individual conduct

International law is most characteristically concerned with regulating the behavior of governments. The laws of war are binding on governments, although national legal systems generally make the laws of war binding on combat personnel and provide criminal sanctions applicable in the event of violations.[4] As well, the Nuremberg approach makes individuals criminally liable for violations of the laws of war even if the violations were committed in the line of duty and in deference to orders issued by bureaucratic or military superiors. That is, international law directs that individual conformity with the laws of war take precedence over normal obligations to domestic law or military and civilian lines of command. The practical consequences of such a directive have engendered many difficulties during the Indochina War for conscientious Americans. The Nuremberg obligation may be taken more seriously in the United States than elsewhere because of a tradition of respect for individual conscience and because the war crimes trials after World War II were so greatly a reflection of American initiative. Daniel Ellsberg and Anthony Russo, draft and tax resisters, and an expanding national movement of civil disobedience all draw support from the wider logic of Nuremberg which implies not only a citizen's duty to refuse participation in illegal war policies or an illegal war, but also creates a legal basis for individual action to prevent governmental crimes of war.

IV

It is now possible to assess the legality of the main components of environmental warfare as it has been waged in Indochina. It is important legally to distinguish between weapons and tactics that are designed to damage the environ-

[3] For range of responses see William J. Bosch, "Judgment on Nuremberg: American Attitudes toward the Major German War-Crime Trials," Chapel Hill, N.C., University of North Carolina Press, 1970.

[4] The Geneva Conventions of 1949 even have a common provision obliging Parties to the treaties "to enact any legislation necessary to provide effective penal sanctions" for persons committing or ordering "grave breaches."

ment and those that, like bombs, are designed to strike human or societal targets, but may also, as a side effect, damage the environment. It is also important to distinguish between specific occasions of environmental warfare and persistent patterns of warfare that produce cumulative effects on ecosystems that can be properly called "ecocide" or policies that can be designated as "ecocidal." And, finally, it is necessary to decide whether the scope of environmental warfare includes the human effects of these weapons. The issue on one level is whether man is to be conceived, for this purpose, as an integral element of "the environment"; at a more practical level the issue is whether human side effects of chemical weapons like 2,4,5–T are to be included in a discussion of environmental warfare.

The problem with the more expansive definition is that all forms of warfare are detrimental to man and his artifacts, and in this sense all warfare could be conceived to be environmental (or ecological) warfare, thereby missing the distinctive feature of American warfare in Indochina and the specific dangers of ecostystem destruction that are posed by high-technology counterinsurgency warfare, especially if carried on in tropical settings. At the same time it is artificial to ignore altogether our own human concerns, and an orientation toward the subject based on a conception of human ecology seems appropriate, wherein bonds between man and nature provide an essential focus for inquiry. Therefore, we define environmental warfare as including all those weapons and tactics which either intend to destroy the environment *per se* or disrupt normal relationships between man and nature on a sustained basis. The focus is on environmental warfare as practiced by the United States in Indochina, rather than on the full gamut of weaponry detrimental to environmental values, which would certainly include biological, radiological, and nuclear weapons as well as those discussed here.

We will consider the legal status following weapons and tactics used in Indochina from this perspective:

(1) The use of herbicides.
(2) The use of Rome Plows to achieve deforestation.
(3) Bombardment and artillery fire.
(4) Reported reliance on weather modification techniques.

1. *The Use of Herbicides.*—There is extensive information available on the use of herbicides in the Indochina War, principally in South Vietnam.[5] The major chemicals used as military herbicides were Agent Orange (a mixture of 2,4–D and 2,4,5–T) used against forest vegetation; Agent White (a mixture of 2,4–D and Picloram) also used mainly against forest vegetation; Agent Blue (Cacodylic Acid) used against rice and other crops. Defense Department figures disclose a steady escalation in the use of chemical herbicides from 1962 up through the early months of 1968, with a slight tapering off up through the middle of 1969 when the last figures were released. In this period, 4,560,600 acres of forest land and 505,000 acres of crop land were sprayed, the total amounting to 5,065,600 acres, or more than 10% of the entire area of South Vietnam (see evidence on Cambodia). The rate of application has been roughly thirteen times the dose recommended for domestic use by the U.S. Drug Administration.

President Richard Nixon reportedly terminated the use of herbicides for crop destruction and announced a phase-out of the defoliation efforts in 1970. Defoliation has not been halted by Nixon, but rather the task has been shifted from chemicals to plows, which from an ecological point of view achieve even more disastrous results.

The environmental damage caused by defoliants can still not be fully assessed. However, there is strong evidence to suggest that some varieties of trees in South Vietnam, particularly nipa palms and mangroves, have been destroyed, not merely defoliated, by a single application; multiple applications kill other trees. The AAAS-HAC study concluded that half of the hardwood trees north and west of Saigon have been damaged. Westing estimates that by December 1970, 35% of South Vietnam's dense forests had been sprayed; 25% once, 10% more than once. Madame Nguyen Thi Binh, speaking in Paris on behalf of the Provisional Revolutionary Government of South Vietnam, alleged that between 1961 and 1969 43% of arable land and 44% of forest land had been sprayed at least once and in many cases two, three, or more times. In this process over 1,293,000 persons were "directly contaminated." [6] John Lewallen concludes: "The forests of South

[5] See esp. J. B. Neilands, G. H. Orians, E. W. Pfeffer, Alje Vennemma, and Arthur H. Westing, "Harvest of Death: Chemical Warfare in Vietnam and Cambodia." New York, Free Press, 1972; John Lewallen, "Ecology of Devastation: Indochina," Baltimore, Md., Penguin, 1971; Thomas Whiteside, "The Withering Rain: America's Herbicidal Folly," New York, Norton, 1971.

[6] Madame Nguyen Thi Binh made this statement at the Paris Peace Conference, Feb. 19, 1970 (quoted in Barry Weissberg, ed., "Ecocide in Indochina," San Francisco, Calif., Canfield Press, 1970, p. 19).

Vietnam have not been merely damaged for decades or centuries to come. Nor have they simply been deprived of rare tree species. It is probable that many areas will experience an ecosystem succession under which forest will be replaced by savanna." [7] Often elephant grass overwhelms a forest area that has been defoliated to such an extent as to prevent reforestation altogether.

There is ample evidence, then, that military herbicides have been extensively used throughout South Vietnam, especially heavily along rivers, estuaries, on villages and base perimeters, and in relation to suspected base areas and supply trails. Defoliants were generally sprayed from the air in specially fitted C–123 cargo planes, often near populated areas and with their dispersal significantly spread beyond intended areas by wind factors. As a consequence, the herbicides contaminated crops, either leading to their destruction or, as the evidence suggests, to teratogenic effects on unborn children. There have been numerous authenticated reports of human and animal poisoning throughout the course of the war.

Military rationale.—The basic military justification for the massive defoliation program was to deny the NLF protective cover, thereby guarding defensive positions against ambush and surprise attack and enabling improved target identification for offensive operations. The destruction of crops was justified as an effort to deny food to NLF forces in areas under their control.

Legal rationale.—The legal rationale of the U.S. Goverment has been well stated by J. Fred Buzhardt, General Counsel to the Department of Defense, in a letter to Senator J. William Fulbright, dated April 5, 1971:

> [N]either the Hague Regulations nor the rules of customary international law applicable to the conduct of war prohibit the use of anti-plant chemicals for defoliation or the destruction of crops, provided that their use against crops does not cause such crops as food to be poisoned by direct contact, and such use must not cause unnecessary destruction of enemy property.
>
> The Geneva Protocol of 1925 adds no prohibitions relating either the use of chemical herbicides or to crop destruction to those above. Bearing in view that neither the legislative history nor the practice of States draw chemical herbicides within its prohibitions, any attempt by the United States to include such agents within the Protocol would be the result of its own policy termination, amounting to a self-denial of the use of weapons. Such a determination is not compelled by the 1907 Hague Regulations, the Geneva Protocol of 1925, or the rules of customary international law.

In essence, the United States Government claims that no existing rules of international law prohibit the military use of herbicides.

Legal appraisal.—It seems clear that an overwhelming majority of governments regards (1) the Geneva Protocol as binding on non-parties, and (2) as extending its prohibition to cover military herbicides. The protocol is binding because it enjoys the status of customary international law, a status that the United States has not seriously challenged. Indeed, the U.S. Government has argued its adherence to the terms of the Protocol, contending only that its prohibition does not extend to military herbicides (or riot control gasses). In submitting the Protocol to the Senate Foreign Relations Committee for ratification Secretary of State William Rogers provided an accompanying statement which said: "It is the United States' understanding of the protocol that it does not prohibit the use in war of riot-control agents and chemical herbicides." [8]

Such an understanding of the scope of the Protocol is not shared by the international community as a whole. UN General Assembly Resolution 2603A (XXIV) supported by a majority of 80–3 (with 36 abstentions) indicated its express intention to dispel "any uncertainty" as to the scope of the Protocol and contained the following operative paragraph:

> *Declares* as contrary to the generally recognized rules of international law as embodied in the Geneva Protocol the use in international armed conflicts of any chemical agents of warfare: chemical substances, whether gaseous, liquid, or solid, which might be employed because of their toxic effects on man, animals, or plants.

This paragraph puts forward a dual basis for disregarding the more restrictive understanding of the Protocol put forward by the American government. First of all, G.A. Resolution 2603A constitutes evidence of what most governments regard the scope of the prohibition to be. Secondly, 2603A is itself supported by a consensus of such a character as to give its law-declaring claims an authoritative status by virtue of the quasi-legislative competence enjoyed by the General Assembly.

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[7] Lewallen, p. 80.

[8] Mr. Rogers' testimony was on March 5, 1971.

This view of the scope of the Geneva Protocol derived from positive international law also accord with the emerging moral consensus and community expectations relating to environmental quality. Hence, when in doubt as to the scope of a treaty rule it seems desirable to seek a determination that accords with unfolding community sentiments. On the level of customary international law, the broad principles of discrimination and proportionality seem at odds with the novel claim to attack vast areas of forest land so as to deprive an adversary of natural cover. It is questionable whether high-technology counterinsurgeney warfare waged against a low-technology opponent can ever be reconciled in its basic character with the framework of restraint provided by the four principles of customary international law. In this sense the problems raised by claims to use military herbicides are but part of a larger set of legal concerns.

On balance, it seems possible to conclude that the American use of military herbicides in Indochina violated the Geneva Protocol, which is both a treaty and a standard of prohibition that enjoys the status of customary international law. This assessment of existing law could be confirmed by seeking an Advisory Opinion on the status and scope of the Geneva Protocol from the International Court of Justice. Such an Advisory Opinion is not really necessary, but if, as expected, it confirmed the interpretation of the Protocol embodied in 2603A then it would lay the American contention to rest once and for all.

When it comes to crop destruction the prohibition on military herbicides stands on even stronger legal ground. As Tom Farer points out, such tactics are "at best indiscriminate, and they may in fact discriminate against civilians because, even if the food supply which survives defoliation was distributed evenly, in absolute terms civilians would suffer disproportionately in that there are more of them and many civilians, the young, for instance, have particularly intense needs for certain foods."[9] Government studies have indeed convincingly shown that crop destruction as in intentional military tactic had the principal effect of reducing the food available to civilians; NLF food requirements were given priority in areas under their control and were small enough in relation to available food to be satisfied. A former high official in the so-called pacification program in Vietnam, L. Craig Johnstone, put the effects of crop destruction as follows: "In the course of investigations of the program in Saigon and in the provinces of Vietnam, I found that the program was having much more profound effects on civilian noncombatants than on the enemy. Evaluations sponsored by a number of official and unofficial agencies have all concluded that a very high percentage of all the food destroyed under the crop destruction program had been destined for civilian, not military use.

The program had its greatest effects on the enemy-controlled civilian populations of central and northern South Vietnam. In Vietnam the crop destruction program created widespread misery and many refugees."[10] Of course, such effects on the civilian population are evidently a central ingredient of counterinsurgent strategy vis-a-vis the countryside, and so crop destruction is fully consistent with such war policies aimed at refugee generation and pacification as "free-fire zones," "harassment and interdiction" artillery fire, forcible removal of refugees, and "search and destroy" missions. The use of chemical herbicides to destroy crops destined for civilian consumption is one of the points where the allegations of ecocide merge with allegations of genocide.

2. *Use of Rome Plows and bulldozing equipment.*—A second major form of warfare waged directly against the environment has been to clear the land of vegetation by means of systematic plowing. According to Paul R. Ehrlich and John P. Holdren:

> Perhaps the crudest tool the United States is using to destroy the ecology in Indochina is the 'Rome plow.' This is a heavily armored D7E caterpillar bulldozer with a 2.5 ton blade. The Rome plow can cut a swath through the heaviest forest. It has been used to clear several hundred yards on each side of all main roads in South Vietnam. In mid-1971 five land clearing companies were at work, each with some thirty plows, mowing down Vietnamese forests. By then some 800,000 acres had been cleared and the clearing was continuing at a rate of about 2,000 acres (3 square miles) daily.[11]

Pfeiffer and Westing conclude that by 1971 Rome plowing "had apparently replaced the use of herbicides to deny forest cover and sanctuary to the other side." They conclude the Rome plowing is more effective than chemicals and "is probably more destructive of the environment." This tactic has been used to "scrape clean

[9] Tom J. Farer, "The Laws of War 25 Years After Nuremberg," *International Conciliation*, No. 583, May 1971, p. 20.
[10] Johnstone, "Ecocide and the Geneva Protocol," Foreign Affairs, Vol. 49, pp. 711-720, at 719.
[11] "Ecocide in Indochina" (mimeo. paper), Dec. 1971, p. 2.

the remaining few areas of the Boi Loi Woods northwest of Saigon." Pfeiffer and Westing visited an area of forest that had been plowed several years previously and it was covered with cogon grass which, according to these experts, makes "further successional stages to the original hardwood forest very unlikely."[12] It is clear that such plowing inflicts ecological damage that may last for a very long period of time, perhaps permanently.

Legal rationale.—As far as I am aware, no attempt has been made to defend Rome plowing as a legitimate tactic of war. A defense of this practice, if attempted, would undoubtedly rest on the argument that it is a legitimate military objective to deny the enemy protective cover and that, in any event, no rules of prohibition can be discovered in either Treaty or customary international law.

Legal Appraisal.—All of the law of war was drafted and evolved in a pre-ecological frame of mind. There are no standards or rules that contemplated a military strategy that sought to destroy the environment as such. Article 22 of the Annex to the Hague Convention on Land Warfare could be relevant in interpreting present content: "the right of belligerents to adopt means of injuring the enemy is not unlimited." The United States Supreme Court often interprets Constitutional norms as embracing conduct not contemplated at the time of ratification, but reflecting an evolving sense of limits within the world community.

Nevertheless, I think it is not easy to conclude that Rome plowing, however much it offends ecological consciousness, constitutes a violation of existing standards of international law. It points up the need for the formulation of clear standards of prohibition, in a new Protocol on Environmental Warfare (Annex 2).

Finally, it is possible to view such environmental devastation as an instance of "a crime against humanity" in the Nuremberg sense, suggesting again the quasi-legislative potentialities created in a situation of moral outrage. The link between environmental destruction of the Vietnamese forests and crimes against humanity is by way of "human ecology," the environment being interrelated in organic fashion with human existence.

Indeed there is some relatively hard evidence to support such an inference. In the official history of the UN War Crimes Commission there is the following report:

> During the final months of its existence the Committee was asked in a Polish case (Commission No. 7150) to determine whether ten Germans, all of whom had been heads of various Departments in the Forestry Administration in Poland during the German occupation (1939–1944), could be listed as war criminals on a charge of pillaging Polish public property. It was alleged that the accused in their official capacities caused the wholesale cutting of Polish timber to an extent far in excess of what was necessary to preserve the timber resources of the country, with a loss to the Polish nation of the sum of 6,525,000,000 zloty. It was pointed out that the Germans, who had been among the first as a nation to foster scientific forestry, had entered Poland and wilfully felled the Polish forests without the least regard to the basic principles of forestry. The Polish representative presented a copy of a circular signed by Goering under date of 25th January, 1940, in which were laid down principles for a policy of ruthless exploitation of Polish forestry. It was decided by the Committee that prima facie existence of a war crime had been shown and nine of the officials charged were listed as accused war criminals.[13]

3. *Bombardment and artillery fire.*—Pfeiffer and Westing have usefully summarized the general information available:

> In the seven years between 1965 and 1971 the U.S. military forces exploded 26 billion pounds (13 million tons) of munitions in Indochina, half from the air and half from weapons on the ground. . . . For the people as a whole it represents an average of 142 pounds of explosive per acre of land and 584 pounds per person . . . most of the bombardment was concentrated in time (within the years from 1967 on) and in area. Of the 26 billion pounds, 21 billion were exploded within South Vietnam, one billion in North Vietnam, and 2.6 billion in Southern Laos.[14]

These awesome statistics will be further augmented by the escalation of bombing in 1972 to the highest levels of the war. Unlike categories I and II practices,

[12] Arthur W. Westing and E. W. Pfeiffer, "The Cratering of Indochina," *Scientific American*, Vol. 226, May 1972, pp. 26–29, at 26–28.

[13] "History of the UN War Crimes Commission and the Development of the Laws of War," London, 1948, p. 496.

[14] Westing and Pfeiffer, p. 21.

category III practices are not designed, *per se*, to destroy the environment. The element of intentionality is probably absent, although with the accumulation of experience the environmental consequence of bombing patterns becomes part of what is known by the war planners.

On the basis of the evidence available it is clear that several distinct patterns of ordinance use should be separately considered for purposes of legal analysis:

Craterization.—Pfeiffer and Westing estimate 26 million craters, covering an area of 423,000 acres, and representing a displacement of about 3.4 billion cubic yards of earth. Much of the cratering has been caused by 500 pound bombs dropped from high altitude B–52 flights and from large artillery shells. Such a bomb typically produces a crater that is thirty to forty feet wide and five to twenty feet deep (depending on topographical conditions), although larger craters have been reported. The effects of craters are numerous:

(1) Arable and timber land are withdrawn from use virtually indefinitely.[15]

(2) Unexploded bombs or fragments make neighboring land unsatisfactory for normal use and cause injury to man and animals.

(3) Craters that penetrate the water table become breeding grounds for mosquitoes, increasing the incidence of malaria and dengue fever.

(4) Craters displace soil, and especially in hilly areas accentuate soil runoff and erosion, causing laterization of the land in and around craters.

(5) Bombardment of forest areas has harmed the timber industry by outright destruction; also, metal shrads weaken trees and make them vulnerable to fungus infection.

Legal rationale.—The bombardment involves legitimate bombardment of suspected concentrations of enemy troops or supplies. Environmental damage is an unintended side-effect that is not regulated in any way by existing international law. To the extent the bombing is indiscriminate then it is subject to independent attack. The demonstration of environmental damage adds little to the legal analysis of the status of Indochina bombing patterns.

Legal appraisal.—It is true that no explicit rules of prohibition seem available to assess the legal status of craterization. However, the scale and magnitude of bombardment raises special issues under Article 22 of the Annex to the Hague Convention on Land Warfare and in relation to Crimes Against Humanity as specified at Nuremberg.

It does seem desirable, nevertheless, to seek new legal rules and principles that are explicitly concerned with the environmental side-effects of standard war policies. Also it is necessary in this context to regard belligerent action beyond the capacity of the environment to absorb and respond in a short period of time as involving the independent crime of ecocide.

Would a Nuremberg II tribunal convened to assess liability of American leaders for craterization in Indochina convict on this count? It is difficult to predict the outcome on this issue because the law is murky and because of an apparent absence of a direct intent to destroy the environment on the part of American civilian and military leaders.

"Daisy-cutters."—Gigantic bombs, weighing 15,000 pounds, were being dropped at an estimated rate of two per week since mid-1971 in South Vietnam to establish instant clearings for firebase helicopter landing areas, and, according to some accounts, on areas of suspected troop concentrations. These bombs kill all animals and people who happen to be within a quarter-mile radius of the blast. The cleared area is completely deforested.

Legal rationale.—Bombing and damage incidental to valid military purpose in a context where no rule of prohibition exists.

Legal appraisal.—The specific action does not seem to violate positive norms of international law. Condemnation is partly an expression of outrage in relation to overall devastation of Indochina and partly an expression of an emerging ecological consciousness. Again, the legal retroactivity of prohibition in a Nuremberg II setting would be more than offset by a sense that such bombs are indiscriminate in effect and disrupt in fundamental fashion man's links to the environment.

Electronic battlefield; systematic bombing; "free-fire zones."—In these settings bombing patterns are indiscriminate with respect to all that breathes and moves. The saturation bombing also devastates the land and tends to depopulate the area subject to attack. Fred Branfman has described in agonizing detail the total destruction of the idyllic and prosperous agricultural subsociety of 50,000 in the Plaine des Jarres in Laos.[16]

[15] Same 24.

[16] Fred Branfman, ed., "Voices from the Plain of Jars," New York, Harper Colophon, 1972.

Legal rationale.—There is none. The facts have been officially repressed or distorted by the U.S. Government.

Legal appraisal.—To the extent these war policies involve attacks on civilian targets, such as rural villages, they are clearly in violation of international law. To the extent that the separate acts of environmental destruction are considered the legal status is, at present, more problematic. To the extent that an inhabited ecosystem, such as the Plaine des Jarres, is devastated by direct action. then it seems to be a crime against humanity in the spirit of Nuremberg I.

4. *Weather Modification.*[17]—There is an increasing indication that the United States has seeded clouds over Laos in order to increase rainfall. The military rationale for such a tactic is to muddy or cause flooding in the vicinity of the network of roadways constituting the Ho Chi Minh trail. A cloud-seeding plane like a reconnaisance plane that drops flares could accomplish its mission by dropping 35 to 100 pounds of silver iodine over a six-hour period. The Defense Department has shrouded the subject in secrecy and has refused to make any statements of unequivocal denial or confirmation. Nevertheless, a series of collateral accounts, including some references in the Pentagon Papers and some leaked information appearing on March 18, 1971, in a news column by Jack Anderson create a strong basis for believing that weather modification has been used in Indochina as a deliberate weapon of war.

Such tactics, because of their relative covertness and widespread potential for devastating impacts on a target area (and, perhaps, on global weather patterns as well) pose a danger of great magnitude to the future of world order. It seems very important to arouse public concern at this time and seek a clearcut prohibition on weather modification for military purposes.[18]

Because of the secrecy surrounding the activity and its novelty in the history of warfare, it is virtually impossible to carry legal analysis any further at this stage. Even more so than poison gas and bacteriological weapons, weather modification poses dangers of indiscriminate and uncontrollable damage, clearly a menacing genie that needs to be recaptured and confined for all time. It seems mandatory in such circumstances to seek an absolute legal prohibition on the practice of weather modification for military purposes.

On the basis of this brief description of the legal status of the main elements of environmental warfare in Indochina it seems clear that there are two distinct sets of tasks:

(1) To take steps to strengthen and clarify international law with respect to the prohibition of weapons and tactics that inflict environmental damage, and designate as a distinct crime those cumulative war effects that do not merely disrupt, but substantially and irreversibly destroy a distinct ecosystem.

(2) To take steps to stop and rectify the ecological devastation of Indochina, to censure the United States for these actions, to impose upon the United States a minimum burden of making available ample resources to permit ecological rehabilitation to the extent possible in the shortest time and in the most humane manner, and to assess fully the various ecological effects of the war upon Indochina.

To accomplish (1) we suggest the following action, illustrated by draft instruments:

A Proposed International Convention on the Crime of Ecocide (Annex 1).

A Draft Protocol on Environmental Warfare (Annex 2).

A Draft Petition, to be signed by individuals and non-governmental organizations, addressed to the Secretary General of the United Nations (Annex 3).

To deal with the more specific problems generated by the Indochina War we propose the following:

A Draft Peoples Petition of Redress on Ecocide and Environmental Warfare addressed to governments and to the United Nations (Annex 4).

VI

There are special difficulties that pertain to taking appropriate legal action with respect to environmental devastation in Indochina. First of all, the United States as a preeminent state in the world system is able to block serious inquiry into this

[17] This section relies upon Deborah Shapley, "Rainmaking: Rumored Use Over Laos Alarms Arms Experts, Scientists," *Science*, Vol. 176, 16 June 1972, pp. 1216-1220.

[18] Senator Claiborne Pell "strongly believes" that clouds in North Vietnam have been seeded since 1966, and have caused thousands of deaths by provoking devastating floods. See New York Times, June 27, 1972, p. 12. Apprehension is increased by the connection between rainmaking and confirmed reports that dikes have been bombed.

subject-matter. I believe this obstructive capability accounted for the failure to inscribe the issue of environmental warfare on the agenda of the UN Conference on the Human Environment. Secondly, and relatedly, the United Nations is not able to pursue effective initiatives without the assenting participation of its most powerful Members, especially the United States; the silence of the Organization through a decade of warfare in Indochina is a shocking revelation of the extent to which the Charter is a dead letter whenever its violation is primarily attributable to one of the two superpowers. Thirdly, the United States has not lost the Indochina War in the way in which Germany lost World War II, and as such, its leaders and policies are unlikely to be subjected to critical review by either an independent commission of inquiry or by an intergovernmental tribunal of judgment.

Given these realities, it is necessary to develop an action plan that has some prospect for success. This plan will have to discount the possibilities of relying upon governments or inter-government organizations, although governments that are willing to formulate a critical response, as did Premier Olaf Palme at the Stockholm Conference in June, 1972, help greatly to expose the failure of public institutions to protect public values. Similarly, petitions seeking redress of grievances directed at those institutions entrusted with formal responsibility help to expose institutional responses that sustain or acquiesce in the practice of environmental warfare and ecocide. Such efforts to present petitions emphasize the need to stimulate a world populist movement, both nationally and internationally, as a way of eroding the power of governments over lives and ecological destinies.

The most important arenas of action may be non-governmental in character. At some point it may even be desirable to organize a peoples' commission of inquiry and redress that seeks to focus the facts of environmental devastation and ecocide on Indochina, and to formulate appropriate demands for censure and relief.

On a more fundamental level, the issues of environmental warfare are peculiarly resistant to inter-governmental collaboration because of their apparent link with counterinsurgency warfare. It is the counterinsurgent that tends to pursue the tactics and rely upon the weapons that do the most damage to the environment. That is, governments have a particular interest in being able to use their technological advantages to neutralize whatever advantages of dispersal and maneuverability are enjoyed by an insurgent. In Indochina this technological and tactical gap has led almost all of the serious environmental damage to have been inflicted by the forces aligned with the incumbent government. It can be argued, in addition, that without military herbicides, Rome plowing, and massive airpower, battlefield outcomes would have been decisively in favor of the insurgent forces. Therefore, it would seem to be the case that environmental devastation is a virtually inevitable byproduct of a sustained campaign of counterinsurgency, especially if carried out in the tropics against insurgent forces enjoying a strong base of popular support; in such circumstances not only must the sea be drained to imperil the fish, but its life-supporting ecology must be destroyed as well. Given the prospect of future insurgent challenges, it is unlikely that governments will be agreeable, at least not without a major populist campaign beforehand, to foreclose by assent to legal prohibitions their military options for counterinsurgent response.

This consideration suggests wider grounds for skepticism as to legal responses. Even in the Third World a large technological gap exists between the weaponry and tactics of the government and that of its internal challengers. Throughout the world most governments are confronted by insurgent challenges and seek to use all effective means to defeat them. The common governmental consensus is abetted by arms sales and transfers which make all governments increasingly dependent on high-technology military establishments. From this dependence, the willingness and capability to wage environmental warfare is almost certain to follow.

It needs to be understood that international law, by and large, continues to reflect the perceived self-interest of governments. Both in terms of formation and implementation international law presupposes reciprocal interests in patterns of voluntary compliance. As such, international law is a consensual system. If these interests do not exist or are not perceived to exist, then it is difficult to generate new law or enforce old law in international affairs. This general comment is peculiarly true for the law of war which raises vital questions of governmental survival. Unlike interstate warfare, the insurgent actor is unrepresented in the international legal order, and the law is likely to be shaped to serve the perceived military interests of governments (i.e. actual and potential counterinsurgents).

Such conclusions reinforce our view that the state system is inherently incapable

of organizing the defense of the planet against ecological destruction.[19] As such, the prospects for ecological protection are intimately linked with the prospects of initiating a world populist movement that incorporates the ecological imperative at the same time that it works to secure equity for all men on earth.

Annex 1

A Proposed International Convention on the Crime of Ecocide

The Contracting Parties:

Acting on the belief that ecocide is a crime under international law, contrary to the spirit and aims of the United Nations, and condemned by peoples and governments of good will throughout the world;

Recognizing that we are living in a period of increasing danger of ecological collapse;

Acknowledging that man has consciously and unconsciously inflicted irreparable damage to the environment in times of war and peace;

Being convinced that the pursuit of ecological quality requires international guidelines and procedures for cooperation and enforcement,

Hereby agree:

ARTICLE I

The Contracting Parties confirm that ecocide, whether committed in time of peace or in time of war, is a crime under international law which they undertake to prevent and to punish.

ARTICLE II

In the present Convention, ecocide means any of the following acts committed with intent to disrupt or destroy, in whole or in part, a human ecosystem:

(*a*) The use of weapons of mass destruction, whether nuclear, bacteriological, chemical, or other.

(*b*) The use of chemical herbicides to defoliate and deforest natural forests for miltary purposes.

(*c*) The use of bombs and artillery in such quantity, density, or size as to impair the quality of the soil or to enhance the prospect of diseases dangerous to human beings, animals, or crops.

(*d*) The use of bulldozing equipment to destroy large tracts of forest or cropland for military purposes.

(*e*) The use of techniques designed to increase or decrease rainfall or otherwise modify weather as a weapon of war.

(*f*) The forcible removal of human beings or animals from their habitual places of habitation to expedite the pursuit of military or industrial objectives.

ARTICLE III

The following acts shall be punishable:

(*a*) Ecocide.
(*b*) Conspiracy to commit ecocide.
(*c*) Direct and public incitement to ecocide.
(*d*) Attempt to commit ecocide.
(*e*) Complicity in ecocide.

ARTICLE IV

Persons committing ecocide as defined in Article II or any of the acts described in Article III shall be punished, at least to the extent of being removed for a period of years from any position of leadership of public trust. Constitutionally responsible rulers, public officials, military commanders, or private individuals may all be charged with and convicted of the crimes associated with ecocide as set forth in Article III.

ARTICLE V[1]

The United Nations shall establish a Commission for the Investigation of Ecocide as soon as this Convention comes into force. This Commission shall be composed of fifteen experts on international law and assisted by a staff conversant with ecology. The principal tasks of the Commission shall be to investigate al-

[19] This position is developed in my book "This Endangered Planet: Prospects and Proposals for Human Survival," New York, Random House, 1971.

[1] Article V may be the most controversial provision in this proposal, and could be either deleted altogether or appended as an optional protocol, to enhance the prospects for ratification of the basic Convention.

legations of ecocide whenever made by governments of States, by the principal officer of any international institution whether or not part of the United Nations Organization, by resolution of the General Assembly or Security Council, or by petition signed by at least 1000 private persons. The Commission shall have power of subpoena and to take depositions; all hearings of the Commission shall by open and transcripts of proceedings shall be a matter of public record. If the Commission concludes by majority vote, after investigating the allegations that none of the acts described in Article III has been committed then it shall issue a dismissal of the complaint accompanied by a short statement of reasons. If the Commission concludes, by majority vote, after investigating the allegations that acts within the scope of Article III have been or are being committed then it shall issue a cease and desist order, a statement recommending prosecution or sanction of specific individuals or groups, and a statement of reasons supporting its decisions. The Commission shall also recommend whether prosecution proceeds under national, regional, international or *ad hoc* auspices. Regardless of decision minority members of the Commission may attach dissenting or concurring opinions to the majority decision. In the event of a tie vote in the Commission, the Chairman shall cast a second vote. The Commisssion shall have rule-making capacity to regulate fully its operations to assure full realization of the objectives of this Convention but with due regard for the human rights of individuals as embodied in the United Nations Declaration of Human Rights.

ARTICLE VI

The Contracting Parties undertake to enact, in accordance with their respective Constitutions, the necessary legislation to give effect to the provisions of the present Convention and, in particular, to provide effective penalties for persons guilty of ecocide or any of the other acts enumerated in Article III.

ARTICLE VII

Persons charged with ecocide or any of the other acts enumerated in Article III shall be tried by a competent tribunal of the State in the territory of which the act was committed, or by such international penal tribunal as may have jurisdiction with respect to those Contracting Parties which shall have accepted its jurisdiction.

ARTICLE VIII

Ecocide and the other acts enumerated in Article III shall not be considered as political crimes for the purpose of extradition.

The Contracting Parties pledge themselves in such cases to grant extradition in accordance with their laws and treaties in force.

ARTICLE IX

Any Contracting Party may call upon the competent organs of the United Nations to take such action under the Charter of the United Nations as they consider appropriate for the prevention and suppression of acts of ecocide or any of the other acts enumerated in Article III.

ARTICLE X

Disputes between the Contracting Parties relating to the interpretation, application or fulfillment of the present Convention, including those relating to the responsibility of a State for ecocide or any of the other acts enumerated in Article III, shall be submitted to the International Court of Justice at the request of any of the parties to the dispute.

ARTICLE XI

The present Convention, of which the Chinese, English, French, Russian and Spanish texts are equally authentic, shall bear the date of. . . .

ARTICLE XII

The present Convention shall be open until . . . for signature on behalf of any Member of the United Nations and of any non-member State to which an invitation to sign has been addressed by the General Assembly.

The present Convention shall be ratified, and the instruments of ratification shall be deposited with the Secretary-General of the United Nations.

After . . . the present Convention may be acceded to on behalf of any Member of the United Nations and of any non-member State which has received an invitation as aforesaid.

Instruments of accession shall be deposited with the Secretary-General of the United Nations.

ARTICLE XIII

Any Contracting Party may at any time, by notification addressed to the Secretary-General of the United Nations, extend the application of the present Convention to all or any of the territories for the conduct of whose foreign relations that Contracting Party is responsible.

ARTICLE XIV

On the day when the first twenty instruments of ratification or accession have been deposited, the Secretary-General shall draw up a *procès-verbal* and transmit a copy of it to each Member of the United Nations and to each of the non-member States contemplated in Article XII.

The present Convention shall come into force on the ninetieth day following the date of deposit of the twentieth instrument of ratification or accession.

Any ratification or accession effected subsequent to the latter date shall become effective on the ninetieth day following the deposit of the instrument of ratification or accession.

ARTICLE XV

The present Convention shall remain in effect for a period of ten years as from the date of its coming into force.

It shall thereafter remain in force for successive periods of five years for such Contracting Parties as have not denounced it at least six months before the expiration of the current period.

Denunciation shall be effected by a written notification addressed to the Secretary-General of the United Nations.

ARTICLE XVI

If, as a result of denunciations the number of Parties to the present Convention should become less than sixteen, the Convention shall cease to be in force as from the date on which the last of these denunciations shall become effective.

ARTICLE XVII

A request for the revision of the present Convention may be made at any time by any Contracting Party by means of a notification in writing addressed to the Secretary-General.

The General Assembly shall decide upon the steps, if any, to be taken in respect of such request.

ARTICLE XVIII

The Secretary-General of the United Nations shall notify all Members of the United Nations and the non-member States contemplated in Article XII of the following:

(*a*) Signatures, ratifications and accessions received in accordance with Article XII.

(*b*) Notifications received in accordance with Article XIII.

(*c*) The date upon which the present Convention comes into force in accordance with Article XIV.

(*d*) Denunciations received in accordance with Article XV.

(*e*) The abrogation of the Convention in accordance with Article XVI.

(*f*) Notifications received in accordance with Article XVII.

ARTICLE XIX

The original of the present Convention shall be deposited in the archives of the United Nations.

A certified copy of the Convention shall be transmitted to all Members of the United Nations and to the non-member States contemplated in Article XII.

ARTICLE XX

The present Convention shall be registered by the Secretary-General of the United Nations on the date of its coming into force.

B

Resolution relating to the study by the International Law Commission of the question of an international criminal jurisdiction.

The General Assembly:

Considering that the discussion of the Convention on the Prevention and Punishment of the Crime of Ecocide has raised the question of the desirability and possibility of having persons charged with ecocide tried by a competent international tribunal;

Considering that, in the course of development of the international community, there will be an increasing need of an international judicial organ for the trial of certain crimes under international law;

Invites the International Law Commission to study the desirability and possibility of establishing an international judicial organ for the trial of persons charged with ecocide or other crimes over which jurisdiction will be conferred upon that organ by international conventions;

Requests the International Law Commission in carrying out this task to pay attention to the possibility of establishing a Criminal Chamber of the International Court of Justice.

Annex 2

Draft Protocol on Environmental Warfare

Considering that environmental warfare has been condemned by public opinion throughout the world and that the deliberate destruction of the environment disrupts the ecological basis of life on earth;

Mindful of the extent to which the future of mankind is linked with the rapid development of protective attitudes toward environmental quality;

Conscious of the extent to which existing and prospective weapons and tactics of warfare, particularly counterinsurgency warfare or reliance on nuclear weapons, disrupt ecological patterns for long periods of time and destroy beneficial relationship between man and nature;

Recalling such prior expressions of collective concern with the general effects of war as expressed in General Assembly Resolutions 1653 (XVI) and 2603A (XXIV);

We, as representatives of governments and as citizens of the world community, do hereby commit ourselves as a matter of conscience and of law to refrain from the use of tactics and weapons of war that inflict irreparable harm to the environment or disrupt fundamental ecological relationships;

This Protocol prohibits in particular:

1. All efforts to defoliate or destroy forests or crops by means of chemicals or bulldozing;

2. Any pattern of bombardment that results in extensive craterization of the land or in deep craters that generate health hazards;

3. Any reliance on weapons of mass destruction of life or any weapons or tactics that are likely to kill or injure large numbers of animals.

We, as undersigned, will seek to gain as many individual and institutional accessions to this Protocol as possible;

The Protocol shall come into effect after the first five signatures and is binding thereafter on all governments of the world because it is a declaration of restraints on warfare that already are embodied in the rules and principles of international law;

Violation of this Protocol shall be deemed an international crime of grave magnitude that can be charged and considered, by fair trial proceedings, wherever an alleged culprit can be apprehended; in cases of extreme necessity trials in absentia are authorized.

Done in Stockholm, Sweden, June, 1972.

Annex 3

Draft Petition on Ecocide and Environmental Warfare

The undersigned:

Mindful of their concern with the ecological quality of this planet and with the purposes and principles of the Charter of the United Nations;

Gravely concerned by the evidence of ecological devastation in Indochina and by the spread of counterinsurgency weaponry and doctrine to governments throughout the world;

Fearful of the further willingness of governments to conduct their operations without due deference for the conditions of ecological welfare, especially during periods of armed conflict.

1. *Declare* that—

(*a*) The commission of acts of ecocide is an international crime in violation of the spirit, letter and aims of the United Nations and, as such, is a direct violation of the Charter of the United Nations and violates the sense of minimum moral obligation prevailing in the world community.

(*b*) The protection of man's relation to natural ecosystems is a legal, moral obligation deserving of the highest respect and directly related to the prospects for human survival and social development.

(*c*) Any government, organization, group or individual that commits, plans, supports, or advocates ecocide shall be considered as committing an international crime of grave magnitude and as acting contrary to the laws of humanity and in violation of the ecological imperative.

2. *Request* the Secretary-General of the United Nations to take the following steps—

(*a*) Convene an emergency session of the Security Council to order the United States to cease and desist from all war policies responsible for the ecological devastation of Indochina.

(*b*) Compile a report on the ecological damage done to Indochina and urge the establishment of a commission of inquiry composed of experts that would submit periodic reports to the General Assembly of ecological effects of the war on Indochina and courses of action, together with funding, available to secure maximum rehabilitation of ecological quality.

(*c*) Request the International Law Commission to prepare an International Convention on Ecocide, a Protocol on Environmental Warfare, and a Code on individual and collective responsibility relative to the crime of ecocide.

(*d*) Convene a conference of governments during 1974 to take appropriate legal steps to outlaw ecocide and to provide the legal framework needed to prohibit environmental warfare, including principles and procedures to assess responsibility and to enjoin activity destructive of environmental values.

Annex 4

Peoples Petition of Redress on Ecocide and Environmental Warfare

The Undersigned:

Recognizing that modern weapons of mass destruction are capable of causing widespread and enduring devastation of the human environment;

Concerned by the evidence of long-term, extensive ecological damage caused in Indochina by a variety of weapons including bombs, napalm, herbicides, plows, and poisonous gases used principally and massively by the United States in the course of waging the Indochina War;

And further concerned by reports of the supply and sale of these means of waging war by the United States to other governments including the Saigon administration of South Vietnam and the government of Portugal;

Do hereby petition all governments to renounce weapons and tactics of war designed to inflict damage to the environment as such;

And call especially on the Government of the United States of America to immediately stop the destruction of the human environment in Indochina and to stop the sale and transfer of weaponry designed primarily to carry on environmental warfare;

And call upon the United Nations to take steps immediately to condemn reliance by the United States on environmental warfare in Indochina, to investigate and report the full extent of ecological damage resulting from the Indochina War; to consider and recommend steps that could be taken to restore the environment in Indochina as rapidly as possible; and to assess responsibility for ecological dam-

age and to call for appropriate reparations from the government(s) responsible after the termination of hostilities;

We further appeal to the United Nations to convene promptly a world conference to draw up an international convention prohibiting recourse to weapons and military tactics designed primarily to destroy or modify the human environment and to prepare a draft convention on Ecocide to parallel the Genocide Convention.

STATEMENT OF REPRESENTATIVE BELLA S. ABZUG FOR THE SUBCOMMITTEE ON OCEANS AND INTERNATIONAL ENVIRONMENT OF THE SENATE COMMITTEE ON FOREIGN AFFAIRS.

Mr. Chairman, Members of the Subcommittee, I am pleased to have the opportunity to present my views on the issue of weather modification for military purposes. Let me begin with two quotations:

> Today, black is the dominant color of the northern and eastern reaches of the Plain [of Jars]. Napalm is dropped regularly to burn off the grass and undergrowth that covers the Plain and fills its many narrow ravines. The fires seem to burn constantly, creating rectangles of black.

That is from "Plain Facts", an article by T. D. Allman which appeared in the Far Eastern Economic Review of January 18, 1972.

There is evidence that herbicides can cause genetic damage:

> Within the last two years, there have been numerous reports of increasing birth abnormalities throughout South Vietnam, and photographs of grotesquely deformed babies have begun to appear in Vietnamese newspapers.

According to "The Indochina Story," written by the Committee of Concerned Asian Scholars, and published by Bantam in 1970.

In addition to the horrors of napalm and herbicide, we are using geophysical warfare in Vietnam. An article by Seymour Hersh in The Washington Evening Star of July 3, 1972, quoted a former CIA agent as saying: "We first used that stuff (silver iodide to seed the rain clouds) in about August of 1963, when the Diem regime was having all that trouble with the Buddhists." The former agent continued, "They would just stand around during demonstrations when the police threw tear gas at them, but we noticed that when the rains came they wouldn't stay on."

As documented in the New York Times by Seymour Hersh, the middle 1960's saw an expansion of the cloud seeding activities to the Ho Chi Minh Supply Trai- in Laos. By 1967, the Air Force had become involved in the cloud seeding operal tions. Yet the results weren't always as expected. One government official has said, as quoted in the July 3 Hersh story, "Once we dumped seven inches of rain in two hours on one of our Special Forces Camps." Professor Jerzy Neyman, director of the University of California's Statistical Laboratory, who has headed a Navy research project analyzing weather control experiments since 1965, "is convinced . . . that cloud seeding does indeed yield significant results, but that the results have often proved far different from what was intended . . ." I consider that, indeed, the cloud seeding in Vietnam could have increased the rainfall considerably," (Neyman has said) . . . "A substantial decrease could also have occurred."

Neyman also found that in Arizona, "during seven years of experimental efforts to relieve drought by cloud seeding, the experiments yielded a significant loss of rainfall over the Santa Catalina Mountain target area, and caused an average 40 percent loss of rainfall over an area 65 miles away."

Despite the unpredictability of cloud seeding, it still appears to be taking place in Indochina. On March 18, 1971, Jack Anderson reported that "Intermediary-Compatriot" a "hush-hush" project which "increased the precipitation over the jungle roadways during the wet seasons . . . would be going on from May to September 1971."

To go into somewhat more detail, Dr. Matthew Meselson, Professor of Biology at Harvard University, has stated that:

> It is obvious that weather modification used as a weapon of war has the potential of causing large scale and quite possibly uncontrolable and unpredictable destruction. Furthermore, such destruction might well have a far greater impact on civilians than on combatants. This would be especially true in areas where subsistence agriculture is practiced in food-deficit areas, and in areas subject to flooding.

The amount of damage we can do through weather modification is tremendous. Tests in Florida in 1968 and 1970 showed that seeded clouds grew explosively and

produced more than three times as much rain as unseeded clouds. Other tests have shown the increase in rain production in seeded clouds could range from 30%–50% to as much as 10 or 20 times that amount. However, even a 50% increase can have tremendous impact.

In their book, "Ecological Effects of Weather Modification: A Problem Analysis," C. F. Cooper and W. C. Jolly refute many of the old theories on weather modification. The false argument that weather control has little or no biological effect because the amount of change is rejected. Instead, the authors state that the weather modification combines with other ecological stresses such as air pollution, herbicides, and pesticides to cause a greater effect than the sum of the individual effects. By using bulldozers, herbicides, and bombings, we clear hundreds of kilometers of natural vegetation, thus destroying the water-holding capacity of the land. Adding the increased rainfall caused by weather modification, the land is plagued with extensive flooding, loss of life, and soil erosion. This destroys balance as well as the possibility of further vegetation.

Two other reports on the ecological damage done by weather modification, "Hydrologic Consequences of Rainfall Augmentation" by Alan M. Lumb which appeared in "American Society of Civil Engineers Hydraulics Divisions Journal" of July 1971 and "Possible Effects of Precipitation Modification of Stream Channels Geometry and Sediment Yield" by Albert Rango, published in "Water Resources Research" in December 1970, agree that increased rainfall causes much land erosion and changing sedimentary patterns.

Weather modification alters the structure of plant and animal communities due to changes in three different biological rates in weather-sensitive species: reproduction, growth, and mortality. These changes may take several years to become evident, but their destructive capacity is considerable.

The most widely used cloud seeding chemical is silver iodide, AgI. The silver ion released from the breakdown of this chemical is one of the most toxic heavy metal ions, especially with regard to microorganisms and fish, but the ion sometimes forms insoluble compounds harmless to animals. The silver from cloud seeding will retard the growth of algae, fungi, bacteria, and fish in fresh water. This in turn interferes with food and nutrient cycles and the return of nutrients to the water. Other biological effects include changes in temperatures, oxygen concentration, presence or absence of other cations, and pH (acidity). So far as we now know, the iodine ion in silver iodide poses no environmental danger.

According to the July 3rd Washington Star article, the use in Indochina of a chemical agent, different from silver iodide, and only effective in warm stratus clouds, has been causing an acidic rainfall which affects trucks, tanks, and radar, especially Surface-to-Air Missile (SAM) radar. This acidity also affects the pH and thus the ecological balance of the ecosystems on which it is dropped.

There has been some dispute as to the suitability for seeding of the types of cloud patterns over North Vietnam. Some have said that the clouds over the northern part of Vietnam are stratus and therefore cannot be seeded successfully with silver iodide. However, Mr. Donald Moore, Assistant Administrator of the National Oceanic and Atmospheric Administration, has stated that he has seen no significant difference in cloud patterns over various areas of Vietnam. He has said that significant cloud pattern changes come with climactic, rather than with minor geographic changes. During the monsoon season, cumulus clouds, which definitely can be seeded successfully, prevail over all of Vietnam. Also, Mr. Schloemer, the Assistant Director of the Environmental Data Service of N. O. A. A., has confirmed Mr. Moore's statement and has added that in the upslope and mountain areas (which would include the Ho Chi Minh trail) there may be a 10% or 15% increase in rain, which means an extra heavy rainfall.

Furthermore, even if they are not suitable for silver iodide seeding, stratus clouds can be seeded by means of the acidic chemical which I mentioned earlier.

On March 17, 1972, Senator Pell submitted Senate Resolution 281, expressing the sense of the Senate that the United States should seek negotiation of a treaty to prohibit the use of environmental or geophysical modification. I applaud and support this action, but I do not think we can wait to negotiate a treaty. We must end the indiscriminate killing and ecological destruction in Indochina now, and I will soon be introducing legislation which would end the United States' use of geophysical warfare. I ask that the text of my bill be printed in the record at the conclusion of my statement.

Congress must take the initiative. Inordinate power has been arrogated to the President, despite the fact that our Constitution establishes the power of Congress to declare war and to make military appropriations. We must—for the sake of the American people and all humanity—reassert our constitutional responsibilities.

The only trouble with rain, as is pointed out in the Sermon on the Mount, is that it falls on the just and unjust alike. The same cloudbursts that flood the Ho Chi Minh trail also wash out the homes and fields of innocent civilians. It is our responsibility to stop the use of weather modification techniques as a weapon of war.

A BILL To prohibit the United States from engaging in weather modification activities for military purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that, notwithstanding any other provision of law, none of the funds authorized to be appropriated by any Act may be obligated or expended—

(1) weather modification activities (including, but not limited to cloud seeding) as weapons of war;

(2) the type of activities carried out by the Department of Defense in Vietnam under the code names of Operation Sherwood Forests, Operation Hot Tip, and Operation Pink Rose in which so-called fire storms or fires over a large area were, or were attempted to be, intentionally ignited;

(3) entering into or carrying out any contract or agreement providing agents, delivery systems, dissemination equipment, or instructions for the military application of weather modification techniques, or for deliberately igniting so-called fire storms or fires over large areas for military purposes (as described in clause (2)); or

(4) procuring or maintaining agents, delivery systems, or dissemination equipment for the purpose of modifying weather conditions for military purposes, or igniting so-called fire storms or fires over large areas for military purposes (as described in clause (2)).

NATIONAL ACADEMY OF SCIENCES,
OFFICE OF THE PRESIDENT,
Washington, D.C., July 25, 1972.

Hon. CLAIBORNE PELL,
U.S. Senate,
Washington, D.C.

DEAR SENATOR PELL: Thank you for your letter of July 14 inviting me to testify before the Subcommittee on Oceans and International Environment of the Senate Committee on Foreign Relations concerning the provisions of Senate Resolution 281. As was indicated to Mr. Keaney on the Committee staff, my absence from Washington prevents me from being available to testify on July 27. I am, however, pleased to submit for your record a statement of my personal views on this proposed resolution. Although I do not speak officially for the membership of the Academy, I am confident that I reflect the views of the great majority of our membership.

S. Resolution 281 would express the sense of the Senate that the United States Government should seek the agreement of other governments to a proposed treaty which would prohibit the use of any environmental or geophysical modification activity as a weapon of war, or the carrying out of any research or experimentation with respect thereto.

At its annual meeting on 26 April 1972, the membership of the Academy adopted a resolution urging that the United States evolve foreign policies that would deemphasize reliance on military force, and employ our national scientific and technological capability for the furtherance of human welfare, the world over. That resolution reads as follows:

"Whereas, the National Academy of Sciences was chartered by Act of Congress in 1863 to provide the federal government with advice on scientific and technological questions, and

Whereas, such a charter carries with it the responsibility to offer its advice on basic issues involving science and technology, the members of the National Academy of Sciences meeting at the 1972 Annual Meeting therefore instruct the President of the Academy to transmit the following resolution: The National Academy of Sciences respectfully requests the President and the Congress of the United States to evolve foreign policies in which the development and application of science and technology in industry, agriculture, and health for the furtherance of human welfare are major elements, and reliance on military force, whether

direct or indirect, is de-emphasized. The Academy stands ready to assist the government in developing and implementing such policies and is eager to cooperate vigorously with scientists and technologists of other countries in furthering these goals."

The position of the National Academy on the deemphasis of military force as an element of foreign policy is consistent with the proposed expression of the sense of the Senate as contained in S. Resolution 281.

I also would like to call your attention to a recent study completed under the auspices of the Academy's National Research Council. While not an official expression of Academy views, the report of that study does give expression to similar concerns by a group of scientists who were selected for their individual competence and judgment in these areas. Specifically, I refer to a 1971 report, entitled "The Atmospheric Sciences and Man's Needs" prepared by our Committee on Atmospheric Sciences.

This report identifies ways in which the atmospheric sciences can contribute to important human needs and deals with the problems of public policy associated with weather modification. The Committee concluded that in their view, the common benefit of mankind would be best served if the United Nations General Assembly were to adopt a resolution, "dedicating all weather-modification efforts to peaceful purposes and establishing, preferably within the framework of international nongovernmental scientific organizations, an advisory mechanism for consideration of weather-modification problems of potential international concern before they reach critical levels." This report also addressed the potential uses of weather modification for military application. The following statement of that report has direct relevance to your consideration. "In view of the unity of the global atmosphere and the complexities and technical uncertainties of the subject, efforts to use weather modification for military advantage would be likely to be ineffective from the strictly military point of view and would at the same time offer the world increased tensions and new dangers."

My personal view is that any large scale intervention in natural energy-transfer processes, whether in the atmosphere, the oceans or beneath the earth's crust, would be highly irresponsible because of our limited understanding of such processes and the results that might occur by such an act. History has been a constant witness to the continuing and appalling refinement by mankind of the instruments of waging war. The recent exponential acceleration of this process, through the application of modern technology, seems hardly to have deterred the willingness of mankind to further refine this process of international violence. Thus the objectives sought in S. Resolution 281 for constraining, through international agreement, experimentation in new uses of technology for developing weapons of war should be given high national priority by the U.S. Government.

Our recent successes in international control, i.e., nuclear test ban, restriction on and uses of chemical and bilogical warfare, and strategic arms control, should most certainly be extended to cover these additional areas of military intervention.

I am aware of those who argue that biological weapons are more "humane" than flamethrowers, TNT, or nuclear weapons, who suggest that induced rainfall that immobilizes the delivery of supplies, is preferable to aircraft dropping laser-guided bombs. And, to honest men, the argument is troubling. But it is surely time that mankind called a halt. It is grotesquely immoral that scientific understanding and technological capabilities developed for human welfare to protect the public health, enhance agricultural productivity, and minimize the natural violence of large storms should be so distorted as to become weapons of war. We are already sufficiently proficient at killing one another, we have already unleashed immense forces we can scarcely control.

The task before mankind is to regain that control, not only to "convert the sword into the plowshare," but to prevent the conversion of newly available or potentially available plowshares into yet newer swords. Before it is too late, our nation, for many years "the last, best hope of man," should return to its almost abandoned position of international moral leadership. An important set of beginnings has already been made, as noted earlier. And the recent agreements resulting from SALT and the President's accomplishments in Moscow are heartening indeed. The self-denying ordinance to avoid the use of growing understanding of the great physical forces operative in the continents, the oceans, and the atmosphere, would be entirely consonant with regaining our own national self-image and without damage to the national security.

Thus, I am pleased to advise of my accord with the goals and objectives which you seek to achieve through the enactment of Senate Resolution 281. I would defer, of course, to others who are more qualified concerning the precise legal wording

or form which such an international agreement should take. In line with the position adopted by the membership of the National Academy, you may be sure that we stand ready to utilize the scientific and technological resources available to us in supporting the purposes set forth in the proposed Senate resolution.

Sincerely yours,

PHILIP HANDLER,
President.

(Excerpt from First Annual Report to the President and the Congress by the National Advisory Committee on Oceans and Atmosphere, dated June 30, 1972, transmitted September 27, 1972.)

WEATHER MODIFICATION

Both deliberate and inadvertent weather modifications are possible today. Potential benefits and potential risks are great and raise grave social, legal, economic, and jurisdictional issues. In this section NACOA discusses the effort it believes desirable in: legislation to define rights, responsibilities, and a sense of purpose; research to hasten and extend our abilities to reduce risks; and international agreement to promote peaceful uses of weather modification and to eschew its hostile uses.

ON THE THRESHOLD OF ENVIRONMENTAL CONTROL

NACOA is persuaded that we stand on the threshold of a new era of environmental control. The scientific literature indicates today, that under certain limited conditions, man can increase or decrease rainfall, increase or decrease snowpack in the mountains, and clear fogs over runways and highways. Claims of suppressing hail in the Soviet Union are impressive. A large-scale effort is now being mounted to develop better methods of hail suppression in the United States. The capability to diminish the force of a hurricane (though not the ability to steer it) seems to be near at hand. Further research and development make it likely that some of today's limitations will soon be removed and man may before long deliberately exert an even greater influence on the weather. These developments require our serious attention now.

Our ability to treat these problems has been increased by advances in mathematical modeling of atmospheric processes, increases in the speed and capacity of computers on which these models are run, and new forms of instrumentation. Delivery systems for cloud seeding (rockets, land-based and airborne nuclei generators) and predictive methods for local meteorological conditions are being rapidly developed. These advances make possible methods of measurement and diminish the reliance on a long expensive series of statistical observations which seek to filter a faint signal from a large background "noise." The result is an acceleration of the entire field.

While our capabilities and understanding are growing, so are the dangers. In some parts of the United States operational weather modification has been carried out for nearly twenty years and operations are also being carried out in many foreign lands. The results are often unrecorded or unpublished. There is also increasing concern that man's activities inadvertently affect the weather and thereby modify the climate. The more we have learned about deliberate weather modification, the more reason we have to be concerned over the inadvertent effects of various substances now being released into the atmosphere. These effects can extend to the global scale as well as being local in nature.

The potential benefits from weather control and conscious climate modification are very large. So are the potential risks—particularly from inadvertent climate modification. Furthermore, any technique enabling man to control large-scale phenomena necessarily raises grave social, legal, and economic issues where effects extend across state and national boundaries. There is still time to address these issues rationally before operational weather modification grows at a pace which forces hasty moves. This opportunity should not be wasted, and NACOA believes that the time has come to take action along several broad fronts.

RECOMMENDATIONS FOR ACTION

NACOA sees five areas in which action is required.

Legislation.—Legislation to define rights and responsibilities of citizens, the States, and the Federal Government is needed promptly. So is legislation to define

means for regulating and licensing private operators, organizational responsibility in the Federal Government, and above all, a sense of national purpose. More specifically, legislation is needed to designate responsibility in ameliorating those weather disturbances that produce public states of emergency, to establish the procedures under which the Federal Government and its employees may legitimately modify the weather, to define the rights and responsibilities of commercial weather modifiers, and to designate responsibility (probably Federal) for monitoring inadvertent weather modification. Regulation is also badly needed, but the issue of separating the responsibility for regulation from promotion of operations, always delicate, deserves more study.

Research and Technology.—Development of the technology by which precipitation can be increased, decreased, and redistributed should be hastened through increased funding for basic research in cloud physics and the optical properties of particulates, for computer modeling, experiment design and field work, and the development of remote-sensing devices (e.g., satellites and Coppler radar).

Hurricanes.—Research and development of the technology to mitigate the effects of hurricanes should be accelerated. This may involve moving Project Stormfury from the Atlantic to the Pacific, where the greater incidence of this type of storm makes the cost-effectiveness much higher.

Public Policy.—A detailed public examination of the policy issues inherent in weather modification should be undertaken. It seems clear that operational weather modification will open the way to substantial social benefits, but the matter of potential social losses cannot be dismissed out of hand. Increasingly the question will be asked "*Who* benefits from weather modification?" All major consequences of large-scale operational programs should be assessed in advance of their implementation. NACOA believes both national and international reporting systems should be developed. Rarely—if ever before—has there been a more attractive opportunity for creative thinking and planning regarding the impact of a potential technological development upon international relations. This opportunity should not be lost.

International.—International agreement should be arrived at and the necessary institutional arrangements developed to eschew the hostile uses of weather modification and to investigate inadvertent changes in the global climate. The Global Atmospheric Research experiment now planned for 1977 can, with some other activities during that period, provide a superb tool for analyzing the vital interaction between long-term oceanic changes and natural or man-made climatic changes. It may be desirable to have an international conference, say in 1974, to discuss issues such as promoting the peaceful use of weather modification and possible collaborative efforts in inadvertent weather modification. The national laboratory dedicated to weather modification, proposed by a National Academy of Sciences study, should be internationalized.

NACOA wishes to associate itself with the position taken by the National Academy of Sciences that in order to safeguard the life-sustaining properties of the atmosphere for the common benefit of mankind, *the U.S. Government is urged to present for adoption by the United Nations General Assembly a resolution dedicating all weather-modification efforts to peaceful purposes and establishing, preferably within the framework of international nongovernmental scientific organization, an advisory mechanism for consideration of weather-modification problems of potential international concern before they reach critical levels.*

HISTORICAL BACKGROUND

Before discussing existing efforts and suggested changes in more detail, it is useful to review briefly the history of weather modification and how we got to the present state. The era of scientific weather modification began in 1946 when Vincent Schaefer and Irving Langmuir demonstrated that it was possible to initiate precipitation by dropping pellets of carbon dioxide from an airplane into a cloud composed of water droplets at below-freezing temperatures. This dramatic development led to Project Cirrus, a broad theoretical and field program intended to establish a strong scientific basis for cloud modification. Perhaps the most important scientific finding was that silver iodide crystals were as effective as dry ice in transforming supercooled clouds into ice-crystal clouds, and thence to rain. More spectacular—and more controversial—were (1) an experiment with seeding a hurricane off the coast, with inconclusive results and (2) experiments by Langmuir that convinced him (but very few others) that periodic seeding of the atmosphere with silver iodide in the southwestern United States produced corresponding periodicities in the rainfall 2,000 miles to the east.

Enough interest was stimulated by Project Cirrus to set in motion two other agency projects. The first was the Cloud Physics Project under the auspices of the U.S. Weather Bureau, the Air Force, and the National Advisory Committee for Aeronautics, conducted from 1948 to 1951. The second was a 5-year Department of Defense project which began in 1952. These serious efforts yielded inconclusive results because of their brevity, the primitive state of the art of instrumentation, and partly because the design of the experiments was not sufficiently sophisticated to filter out the natural variability of the atmosphere.

Meanwhile, a determined band of meteorological entrepreneurs moved in and succeeded in placing nearly ten percent of the land area of the country under commercial seeding, from strategically located silver iodide generators, at an annual cost of between 3 and 5 million dollars. The movement spread to 30 other countries.

Sufficient interest and controversy were generated by these results that Congress established in 1953 an Advisory Committee on Weather Control to study and evaluate the results of private and public experiments. Its report issued in 1958 was cautiously optimistic, concluding that increases of 10 to 15 percent in rainfall were induced by seeding spring and winter storms in the mountainous areas of the western United States. More long-term research was recommended with special responsibilities being assigned to the National Science Foundation. The Advisory Committee report was subjected to considerable attack, primarily on statistical grounds. However, the NSF did mount a modest but sound program of fundamental research and field experimentation, which laid an important basis for the next decade. As a result of extravagant claims and questionable practices by a few commercial cloud seeders, and controversy on statistical interpretation of experimental results, the field did not flourish during the early 1960's.

A two-pronged study was initiated in 1963 and 1964, by the National Academy of Sciences and a Special Commission of the National Science Board. Their reports, issued early in 1966, were moderately optimistic. The conclusions of the 1953 Advisory Committee that the order of a 10-percent increase in precipitation can be expected from seeding orographic storms in western United States were substantiated. Subsequent studies by the Academy and the Interdepartmental Committee for Atmospheric Sciences have reinforced early findings.

PRESENT STATE OF THE ART

For certain meteorological conditions the evidence is persuasive that it is possible to increase precipitation by substantial amounts and on other occasions to decrease precipitation by substantial amounts.

There is ambiguous evidence that the effects of seeding may influence precipitation at points 100 to 200 kilometers from the site of the seeding. This matter must be clarified.

It now appears possible to acquire the additional knowledge necessary to predict the effects of seeding on a wide variety of cloud types and systems (convective, orographic, stratiform, migratory storm systems, etc.) in different geographic areas from reasonably realistic computerized cloud models.

Supercooled fog can be dissipated on an operational basis.

There is encouraging evidence that hail can be suppressed.

There is encouraging evidence that the intensity of winds in a hurricane can be reduced.

There is evidence that further development will lead to operational techniques for decreasing the frequency and duration of cloud-to-ground lightning discharges, with a subsequent reduction in forest fires.

Advances in remote-sensing techniques are the first steps toward methods to modify tornadoes.

No completely accepted technique yet exists for dissipating warm fog, but the the potential economic benefits and the encouraging prospects of such a capability warrant further research.

The prospects of inadvertent modification of weather and climate by changing the chemical composition of the atmosphere, the particle concentration, or by the discharge of heat are so real, and so likely to be realized within a matter of decades, that a major program of research appears to be warranted.

Weather modification issues now reach to the stratosphere. It has been suggested that exhaust emissions from SST's may decrease the ozone concentration at high altitude and lead to an increase in ultraviolet radiation at the Earth's surface. Fortunately, the way appears clear to resolve this question before SST's are operational.

Ongoing national projects

The Federal programs in weather modification are coordinated under the Interdepartmental Committee for Atmospheric Science (ICAS) of the Federal Committee for Science and Technology. A number of the research projects representing voluntary combinations of resources of several of the interested Federal agencies are National Projects. They include snowpack augmentation, surface-wind reduction in hurricanes, increase of natural rainfall in areas where needed, reduction of damaging hailfall, spreading heavy Great Lakes snowfall over a wider area, and improving visibility in warm and cold fogs. Though agency funding for weather modification has lately been increased—in the last 2 years from $16 million (FY '71) to $20 million (FY '72 Estimate) to $25 million (FY '73 Budget)—the projects have characteristically been inadequately coordinated, underfunded through fragmentation, often not backed up by basic research, and undertaken with obsolete equipment. This is not a criticism of any specific project, but of the lack of central planning and execution.

SOME POTENTIAL BENEFITS

Although too much reliance should not be placed on benefit-to-cost analysis, attractive ratios are already being achieved in some areas of weather modification. The Southern California Edison Project in the upper San Joaquin River Basin in the Sierra Nevada range has been operated continuously every winter since the 1950–51 season. Although the exact figures are proprietary, the meteorologist in charge reports that annual runoff has been increased 8 percent over the lifetime of the project.[1] Bureau of Reclamation studies indicate something like a 10 to 1 ratio of benefit-to-cost for orographic precipitation enhancement of this sort.[2] However, these operational programs are limited in number and have remained relatively constant through many years. Many programs having large potential benefits at attractive operational costs are not operational today due to limitations in the present technology. This translates to limitations on the resources (laboratory facilities, scientific manpower, instrumented aircraft, computer time, etc.) necessary to improve the technology.

Hail suppression has been operational in the USSR for many years with reported benefit-to-cost ratios of as high as 17 to 1. Lightning-caused forest fires produce losses in excess of $100 million annually and destroy valuable forests. An operational technique for lightning suppression is expected to yield a benefit-to-cost ratio of at least 5 to 1. A semioperational program in Alaska now beginning its fourth season reflected this ratio in the 1971 summer season. Cold fog dispersal over airport runways is now operational, where this type of fog is prevalent, with a return in benefits six times the cost of the program. Warm fog is even more prevalent, and it seems likely that a similar benefit-to-cost ratio will be attained when the operational techniques for its dispersal are perfected.

It is estimated that the hurricane modification program alone, when operational, would cost about $5 million annually and could reduce property damage and related costs by $100 million annually, a benefit-to-cost ratio of 20 to 1.

There is another vast area which suffers a shortage of annual precipitation, reaching drought proportions in far too many years. This is the northern Great Plains area of the country. In this region, where summer rainfall is both scanty and sporadic, crop-production technique is based on trapping a portion of 1 year's rainfall to help support grain production in the subsequent year, and one crop is produced each 2 years per unit of land area. On the basis of soil quality, the potential exists for annual crops given a modest increase in rainfall. This area, which has been largely ignored by the Federal Government in its weather modification program, should be explored.

TECHNICAL OBSTACLES TO PROGRESS

Progress in any technical endeavor depends upon our theoretical understanding, our ability to measure, our facilities for experimentation, and our ability to mount and manage large-scale field experiments. We have made significant progress in all four areas in the last decade.

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[1] Private communication from Robert D. Elliott, North American Weather Consultants, Santa Barbara, Calif.

[2] "Some Considerations of Benefit-to-Cost Relationships Regarding Use of Weather Modification," by Loren W. Crow, April 7, 1972, Contract to NOAA, LWC #99.

Understanding

In order to make progress in the National Projects and other applications of weather modification, a great deal more must be learned about the natural weather processes and how these processes can be modified to bring about the desired effect. Some of these areas where measurements are essential include: origin, detection, and counting of natural ice nuclei; modes of nucleation, optimum particle size and numbers, and inadvertent sources of artificial ice nuclei; detection, counting, and variability of natural cloud condensation nuclei; inadvertent sources of artificial cloud condensation nuclei; water vapor, liquid water, rate of riming, cloud drop size, etc.; ice crystal type and size; and temperature in cloud, vertical and horizontal flow, electrical field, etc.

Instrumentation

The key to increasing our knowledge of the processes involved is accurate measurements of all of the needed information. This requires development of instruments and the means to test and calibrate these instruments under actual or simulated conditions. The priority areas requiring attention are: (1) airborne instrumentation that can rapidly and accurately provide measurement of the type discussed in the preceding paragraph; and (2) more effective nucleating agents and more efficient methods of getting the nucleating agents into the target area.

Significant progress has been made in recent years in satellite technology and in remote sensing from aircraft and from the ground. NOAA's coming high resolution geostationary satellite and its developments in Doppler and optical radars and other remote-sensing techniques will make significant contributions to the advancement of the technology of weather modification. Satellites and remote sensing should be able to tell us something of the physical changes taking place within the seeded cloud and thus aid in the evaluation of field experiments.

In the final analysis, however, it is the precipitation on the ground and the runoff into the rivers and reservoirs that count where precipitation enhancement is the goal. Measuring the true difference in precipitation and runoff between seeded and unseeded areas continues to be the best hope for assessing results, but a vast improvement in this area is needed. Here radar, in combination with recording rain gages, represents the primary hope.

FACILITIES

A significant one-time investment in facilities will be required in order to support the developmental programs. The more important of these include:

Cloud chambers to stimulate the natural environment to enable the study of the natural processes involved and how they are affected by artificial stimulation.

A test and calibration facility. NOAA has in operation the analog to what is needed here, i.e., National Oceanographic Instrumentation Center. Here new instrumentation developed by both public and private organizations are tested in modern facilities, and reports are issued as to their accuracy, reliability, maintainability, etc. The Center also provides a calibration service to both public and private organizations. Such a facility is urgently needed in the weather modification field.

Modern well-instrumented aircraft. A majority of the needed aircraft already exist in the private sector. The Federal Government need only be concerned with providing the minimum number of heavy aircraft equipped with sensing and recording systems, radars, and seeding capabilities required of the program. NACOA notes with concern the need to cancel NOAA's planned move of its hurricane modification project (Project Stormfury) to the Pacific for lack of such aircraft.

Field experimentation

As discussed previously, the Federal agencies are currently engaged in a variety of field programs. In almost every case the field programs are restricted by limited resources of one kind or another to the point where the programs are suboptimal and progress has been at a snail's pace. One would hope that the primary objectives of Federal programs to enhance rainfall, eliminate fog, and suppress hail and lightning would be the transfer of this technology to the private sector where it could produce an expansion of existing industries and create new ones.

What is badly needed is a field experiment which brings to bear all of the resources that can contribute to the success of the experiment. The experimental area might be somewhere in the Great Plains and should operate on a year-around basis. Experiments should be carried out with summer cumulus, winter upslope stratus, and winter migratory storms. The program should employ the latest in

meteorological satellite and remote-sensing technologies, well-instrumented aircraft, and an increased density of surface, upper air, and radar observations of the National Weather Service. The emphasis should be on providing the tools necessary to fully measure and observe the physical and dynamic changes taking place both naturally and under the influence of seeding. Maximum effort should be made to determine results through direct observation of the changes in the cloud. In addition, the experiment should be designed in such a way as to provide optimum conditions for a statistical evaluation (e.g., random crossover design). The technologies developed by NOAA in Florida with dynamic seeding of tropical cumulus, by NOAA with seeding of low stratiform clouds over the Great Lakes, and by Bureau of Reclamation supported programs in the Dakotas and Texas provide the initial groundwork for this effort. The field experiment should be concentrated in an area less than the size of a State. From this experiment should come the basic knowledge which is needed for most phases of weather modification.

INSTITUTIONAL FACTORS AND REGULATION

Weather modification today within the Federal Government is carried out by seven agencies to meet their individual mission needs. The Department of Transportation is concerned with the effect of fog on airport operations, the Department of Agriculture is concerned with the reduction of lightning-caused forest fires, the Department of the Interior is interested in increasing the water supplies in the West, and the Department of Commerce is interested in abating hurricanes and other severe storms and in reducing or increasing precipitation for a wide variety of purposes. What is lacking is a central focus for the overall effort. Some progress has been made in this direction with NOAA having been assigned responsibility for monitoring the weather modification activities within the country, both Federal and non-Federal. More importantly, though, is the need to have a single Federal agency responsible for taking the lead in development of the technology of the overall program. The present fragmented approach is moving the country ahead in weather modification in an erratic fashion.

Certain basic facilities and services which represent common needs of most Federal programs do not exist. Instrument development programs are critical to progress in weather modification, yet no focused program in this area is in evidence. There is a strong need for a central Federal facility to test, evaluate, and calibrate instrumentation and equipment used in field experiments. Again, no such facility exists. The lead agency should be responsible for doing the type of field experiment recommended for the Great Plains area. It should focus on drawing on the research results of the NSF and other Federal agencies and testing these in an operational environment. The end objective would be a feedback to the mission-oriented programs of the other Federal agencies, and a technology transfer to the private weather modification sector.

There is an immediate need for some form of regulation. As the Federal Government invests increasing resources in major field projects such as the National Hail Research Experiment and the Great Plains project, it becomes imperative that these experiments not be compromised by other seeding activities on their peripheries. To illustrate the problem, there recently was a test carried out to determine whether a seeding program upstream of a field project could be affecting the project. The results showed that 20 to 30 percent of the seeding agent introduced 100 miles upstream was actually contaminating the field project. In addition, the National Science Foundation has reported that two major weather modification projects supported by the NSF in the western United States were seriously compromised by unregulated cloud seeding in the vicinity of the projects. In one of the cases, the Foundation investment of over a quarter of a million dollars was negated by the lack of regulation.

Regulation at this time should be the minimum necessary to ensure that critical Federal experiments are not vitiated as a result of contamination by a nearby seeding activity and to ensure that all commercial operators are licensed and meet certain specified standards to protect the populace from unsafe seeding procedures.

EVALUATION

Experimental weather modification is an activity that does not lend itself to demonstrating a precise connection between actions and outcomes. The accuracy of assessment after the fact can be increased by better use of advanced instrumentation such as geostationary satellites, modern radars, computer models, aircraft probes, nuclei counters, etc. However, even with the best of instrumentation it is

impossible to measure all variables over a region of several hundreds of square miles. Even with unlimited funding, exact evaluation of an experiment is not possible. In the case of operational weather modifications, there are economic limits to the instrumentation that can be afforded. Therefore, decisions regarding operation must be made with only part of the data at hand. Whether the missing data are of serious consequences depend upon the specific circumstances. If operational weather modification is to be more generally applied, the decision making apparatus for determining when and how to permit operations needs to be improved.

Therefore, NACOA wishes to emphasize need to integrate statistical and other analytical approaches (most computer modeling) to reduce the uncertainty in evaluating the efficacy of weather modification. NACOA urges all agencies that sponsor research and development in weather modification, and all those who conduct operations, to explore and utilize both statistical and nonstatistical techniques and to conduct studies designed to bring these approaches together.

(Excerpt from Comments and Recommendations of the Secretary of Commerce on the First Annual Report of the National Advisory Committee on Oceans and Atmosphere, transmitted September 27, 1972.)

WEATHER MODIFICATION

I believe that NACOA has correctly assessed the exciting outlook in the field of weather modification. There is no question that developments of the last decade have put us on the threshold of weather control. To realize the potential of this new technology, the Committee urges action in the field of legislation, research and technology, hurricane control, public policy and international relations.

I welcome both the Committee's analysis of the present status of weather modification technology and its many recommendations for action. The present national plans for development of this field closely follow many of the suggestions of the Committee. The public policy positions, especially as they relate to the international aspects of weather modification and our posture in this field, are being studied by the Administration. The Committee's views on these matters will be considered in the course of these studies.

The need for Federal legislation to define the rights and responsibilities of citizens, States, and the Federal Government; to establish regulatory mechanisms and liability provisions; and to protect the public is strongly supported by NACOA. Along these lines this Administration recommended legislation that has been enacted requiring the reporting of all weather modification activity to the Secretary of Commerce. I welcome the views of the Committee concerning the need for further legislation.

The analysis of national needs for research and technology in weather modification is a balanced and comprehensive treatment. The findings and recommendations offer a sound basis for further development of the national effort.

The review of the technical obstacles to progress in this field provides a framework for organizing our scientific effort, directed at understanding critical physical processes, and for our technological development effort in instrumentation and facilities. The call of the Committee for an expanded field effort in the Great Plains region of the United States is welcomed, and initial plans for such an effort are being prepared.

Some concern has been expressed by NACOA about the fragmentation of effort among the many agencies of the Federal Government, and NACOA recommends that a single Federal Agency take the lead in the development of the technology of weather modification. I agree with this recommendation for establishment of a central focus within the United States Government for carrying out research and development in all phases of weather modification. However, I believe that weather modification technology should remain available for use by all agencies of the Federal Government in the discharge of their mission responsibilities. It would also be unwise to divorce the necessary supporting research that would be required for the application of weather modification techniques from the agency with responsibility for such application.

The Committee has given special attention to the national effort in hurricane modification. I agree that this effort represents one that must be fostered at an accelerated pace. I welcome the views of NACOA on this issue, as we develop our plans for this effort.

The Committee's concern for the public policy issues is deeply appreciated. Weather modification carries with it the potential for social gain, but not without

the threat of concomitant social losses. It is clear that careful technological assessments of the consequences of the application of weather modification are required before decisions for widespread use are made. There is no question that we do not know enough at the present about many of the public policy issues involved, and they require continuing study. Studies are already being sponsored by the National Science Foundation and NOAA.

The realization that weather modification has critical international implications is strongly emphasized by NACOA. The Administration is conscious of these implications and welcomes NACOA's views on these matters. It is the policy of this Administration to foster international collaboration in this field to the maximum extent possible. We are moving to follow up the recommendations of the United Nations Conference on the Human Environment held in Stockholm this year for the monitoring and study of inadvertent weather modification in cooperation with other nations. We are working closely with all nations of the world on the World Weather Program and its research phase, the Global Atmospheric Research Program. We are continuing our exchanges of scientists with the Soviet Union and other countries in many phases of weather modification, and are extending assistance to developing countries in those instances where weather modification appears to be a useful tool in ameliorating weather-related problems.

U.S. Position Paper on Recommendation III–218

1972 UN Conference on the Human Environment—Position Paper

Subject.—Identification and Control of Pollutants: Climate: III–218

Recommendation.—It is recommended that Governments be especially mindful of activities in which there is an appreciable risk of effect on climate, and, (a) carefully evaluate the likelihood and magnitude of climatic effects and disseminate their findings before embarking on such activities, (b) consult fully other interested States when activities carrying a risk of such effects are being contemplated or implemented.

U.S. Position.—The USG has submitted to the Conference Secretariat two editorial changes which if accepted would modify the above recommendation to read as follows:

Recommendation.—It is recommended that Governments be especially mindful of activities in which there is an appreciable risk of effect on climate, and, (a) carefully evaluate the likelihood and magnitude of climatic effects and *to the maximum extent feasible,* disseminate their findings before embarking on such activities, (b) consult fully other interested States *wherever practicable* when activities carrying a risk of such effects are being contemplated or implemented.

If the Conference document does not reflect the proposed U.S. amendments, the delegate should propose such amendments.

His reasons as to (a) should be that as currently worded the recommendation is to some extent unrealistic since the mechanisms by which man's activities might affect climate are largely not known. Hence, the insert—*to the maximum extent feasible*—before "disseminate" their findings.

Amendment to (b) should be similarly supported accompanied by a statement that with regards to possible international effects of activities such as weather modification that might affect climate, the U.S. practice has been to notify and consult with possible affected State's governments to the maximum extent practicable.

If amendments fail then Delegate should not support the recommendation unless he makes a statement to the effect that the recommendation is unrealistic because it fails to take into account the imperfect state of our knowledge as to mechanism by which man's activities might affect climate, and this in turn affects the abilities of Governments to do more than what is feasible and practicable in meeting all the terms of the recommendation.

Discussion.—The U.S. practice with regard to possible international effects of activities such as weather modification that might affect climate has been to notify and consult with possible affected State's governments to the maximum extent feasible. In certain cases, plans have been materially altered to accommodate other government's fears of possible untoward effects on their territories.

Analysis of the global atmospheric monitoring network data is required to evaluate the effects of changes in atmospheric composition on climate. For example, data already collected at baseline monitoring stations, principally at Mauna Loa, Hawaii, show that atmospheric CO_2 has increased by approximately 3.4% (from 312 to 323 ppm) between 1958 and 1971. There is no general agreement within the scientific community as to precisely what effect such a change in CO_2 content

will have on the world climate. Research, analysis, and modeling of such effects is badly needed in order to make rational decisions on the climatic impact of man's activities.

Speech Talking Points.—Worldwide cooperation is important. If one nation, or even several, follow the Recommendation, and others do not, the idea will fail. As man's technology continues to grow, his capacity to affect his environment and even the climate itself will expand; ultimately, if not in fact already, the stakes of all nations, indeed of all mankind, in the concept of international cooperation in environmental protection will become immense.

The U.S. Delegation should note that the first part of the Recommendation is to some extent unrealistic since the mechanisms by which man's activities might affect climate are to a great extent imperfectly known. Hence, the recommendations on analysis of the monitoring data and research on the modeling of climatic effects of pollutants are of prime significance to realizing the goals of the Recommendation.

Concept of Cost, Resources, and Timing of Carrying Out Recommendation.—The costs and resources required for carrying out the internal evaluation of activities required by this Recommendation should be borne or supplied by each State. Judging by the U.S. experience so far, such costs and resources should not prove burdensome. Members should be encouraged to set up such controls as soon as possible.

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