WEATHER WARFARE: LAW AND POLICY

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Almighty and most merciful Father, we humbly beseech Thee, of Thy great goodness, to restrain these immoderate rains with which we have had to contend. Grant us fair weather for Battle.[1]

During the Battle of the Bulge in December 1944, General George Patton issued cards to troops of the Third Army conveying Christmas greetings on one side and a prayer for fair weather on the other. Clouds and fog had obscured German troop movements and hindered Allied use of air power. A five-day break in the weather started the day after the cards were distributed, "and when clear weather came [Patton] was sure he had a Chaplain with powerful influence in Heaven."[2]

For centuries warriors like Patton have preferred to fight when visibility was good and conditions for maneuver were at their best. Rains usually have followed major battles since the dry weather conducive to fighting inevitably must be followed by storms. Some persons have attributed post-battle precipitation to the impact of roaring cannon on the clouds. This impact was noted by Benvenuto Cellini, who asserted in his memoirs that by firing artillery at rain clouds he had averted an impending storm and saved a procession in Rome from being dampened.[3]

History indicates that a commander's beliefs about the weather-war relationship may have tactical significance. General William Howe called off his campaign against General George Washington's beaten Continentals in December 1776 because "gentlemen did not wage war in winter."[4] Washington's brilliant capture of Trenton and rout of the

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1. H. SEMMES, PORTRAIT OF PATTON 231 (1955).
2. *Id.*
3. Ward, *Artificial Rain*, 8 AM. METEOR. SOC'Y J. 484 (1892).
4. S. MORISON, THE OXFORD HISTORY OF THE AMERICAN PEOPLE 243 (1965).

British at Princeton during the Christmas season not only saved the American cause, but also showed that a commander willing to operate when the elements are at their worst can do rather well against troops whose officers are sitting out the bad weather.

The ability to predict weather conditions and plan operations accordingly has been shown to be invaluable to military commanders. American naval forces were "covered" by a cold front in their safe return from the first aircraft carrier raid on Japanese-held islands in the central Pacific early in 1942. The weather officer of the task force flagship told his skipper of the natural smoke screen afforded by the rain, low ceiling and limited visibility associated with the front, and suggested that the returning ships use it for cover from Japanese planes attempting to locate the task force and retaliate against it. The fleet took cover under the clouds, adjusted its speed to the front and returned to Pearl Harbor without being detected by the Japanese patrols.[5]

Meteorologists were also essential advisors to Allied forces in Europe. D-Day was originally planned for June 4, 1944. In fact the troops were loaded aboard ships and ready to go to France. Foul weather brought about postponement of the invasion to the sixth. There was a question whether further delay might be necessary, but forecasters assured General Eisenhower that wind and sea conditions on the sixth would be acceptable. On the strength of their advice the invasion was launched.[6]

Over a quarter of a century after D-Day, rumors began to circulate about a new role for meteorology in warfare. In addition to predicting what nature would provide by way of precipitation, winds and temperatures to help military leaders plan their tactics and strategies, American weather warriors were said to have been involved in efforts to modify weather conditions to make them more favorable for operations in Indochina. These rumors were investigated by columnist Jack Anderson who broke the story to the public in his column of March 18, 1971.[7] The gist of his report was that American rainmakers had attempted to create cloudbursts over the Ho Chi Minh trail network in order to cause flooding along the trails and make them impassable.

The use of weather modification for warfare raises serious questions of fact, of law and of policy. These questions will be discussed in light of reports of American precipitation management efforts in Southeast Asia and estimates of our ability to manipulate the weather.

5. F. VAN STRATEN, WEATHER OR NOT 5-10 (1966).
6. S. MORISON, *supra* note 4, at 1030-31.
7. Washington Post, Mar. 18, 1971, § F, at 7, col. 5.

Legislative responses to these stories and estimates, and the impact of international conventions, customs and principles upon military weather modification will also be considered. Finally, some of the policy considerations relevant to determining the necessity and extent of limitations on the use of weather modification as a weapon will be analyzed.

WEATHER WARFARE

Precipitation Management

The most complete account of rainmaking as a weapon was written by Seymour M. Hersh, a reporter for the *New York Times*. His story, which appeared in the *Times* on July 3, 1972, contained a rather extensive review of military precipitation management in Indochina.[8] He pointed to cloud alteration efforts over Hue, South Vietnam, conducted by the Central Intelligence Agency in August 1963, as the first American use of rainmaking techniques in the Vietnam War. In Hue and a year later in Saigon, demonstrations by opponents of the South Vietnamese government were dampened by artificially induced rainfall.[9]

The Hersh article reported that one government official, who was neither identified nor named in the article, estimated that more than half of the military precipitation management efforts in Southeast Asia in 1969 and 1970 took place in South Vietnam. According to that source, they were widely used, particularly in the north along the Laotian border.[10] Use of weather modification was integrated with ground and air operations. Among the objectives were providing cover for infiltration of South Vietnamese commando and intelligence teams into North Vietnam, dampening areas to hinder North Vietnamese attacks and raids in South Vietnam and diverting enemy men and materiel from military operations to keep open lines of communication and supply.[11]

Rainmaking in Laos has also been the subject of several articles in periodicals[12] as well as Anderson's column,[13] and is mentioned in the Hersh article.[14] One obvious source of these reports is the Gravel

8. N.Y. Times, July 3, 1972, at 1, col. 6. Mr. Hersh has written on other weaponry in Vietnam. S. HERSH, CHEMICAL AND BIOLOGICAL WARFARE: AMERICA'S HIDDEN ARSENAL (1968). He won the Pulitzer Prize for his articles about the Mylai tragedy.
9. N.Y. Times, July 3, 1972, at 2, col. 3.
10. *Id.* at col. 5.
11. *Id.* at col. 3.
12. Purrett, *Weather Modification As A Future Weapon*, 101 SCI. NEWS 254 (1972); Shapley, *Rainmaking: Rumored Use Over Laos Alarms Arms Experts, Scientists*, 176 SCI. 1216 (1972); *The Specter of Meterological Warfare*, 102 SCI NEWS 35 (1972); *Weather Warfare*, SCI. FOR THE PEOPLE, July 1972, at 9; N.Y. Times, July 9, 1972, § 4 (Week in Review), at 3, col. 1; Wash. Post, July 2, 1972, at C1, col. 1.
13. Washington Post, *supra* note 7.
14. N.Y. Times, July 3, 1972, at 2, col. 4.

edition of the Pentagon Papers which includes memoranda of the Joint Chiefs of Staff about Operation Pop Eye, a weather modification undertaking designed to "reduce trafficability along infiltration routes."[15] Anderson spoke of a "hush-hush project known by the code name 'Intermediary-Compatriot,' which was started in 1967 to hamper enemy logistics."[16] In her article on the Laos seeding, Deborah Shapley, a writer for *Science*, noted the secrecy involved in military weather operations with the tart comment: "The generals are probably doing something about the weather, but nobody's talking about it."[17]

Government officials, as well as the military, have had little to say about these weather warfare allegations. Written queries from members of Congress to Department of Defense officials have produced the response that "[c]ertain aspects of our work in this area are classified" because they have "a definite relationship to national security."[18] In response to direct questioning about weather control operations over North Vietnam, former Secretary of Defense Melvin Laird has been quoted as saying: "We have never engaged in that type of activity over North Vietnam."[19] That denial, however, may be interpreted as restricted to military activities during the Nixon administration and is clearly limited to North Vietnam.

Rainmaking over North Vietnam would appear to involve issues beyond those which could be raised in connection with such efforts in the rest of Indochina. The concern over potential or actual flooding of civilian populations would be more pointed. Inducing artificial rainfall, like bombing dikes, might lead to severe loss of life and property among noncombatants.[20] British air raids over the industrial heartland of Germany during the Second World War included successful attacks upon dams. The resultant floods cut electrical power production, flooded factories and caused much loss of life.[21] But that was another

15. 4 THE PENTAGON PAPERS: THE DEFENSE DEPARTMENT HISTORY OF UNITED STATES DECISIONMAKING ON VIETNAM 241 (M. Gravel ed. 1971). *See also id.* at 146.

16. Washington Post, *supra* note 7.

17. Shapley, *supra* note 12.

18. Letter from John S. Foster, Director of Defense Research and Engineering, to Senators Claiborne Pell and Alan Cranston and Representative Gilbert Gude, in PROHIBITING WEATHER MODIFICATION, *Hearings on S. Res. 281 Before a Subcomm. of the Senate Comm. on Foreign Relations*, 92d Cong., 2d Sess. 105-06 (1972) [hereinafter cited as *Hearings*]. For other communications, see *Hearings*, 103-08.

19. Shapley, *supra* note 12, at 1218.

20. One editorial writer has expressed the sentiment that it "is unthinkable and hopefully without basis in fact that the U.S. would have sought to flood North Vietnam by cloud-seeding over the dikes." Ariz. Daily Star, Oct. 6, 1972, § D, at 14, col. 2.

21. P. BRICKHILL, THE DAM BUSTERS (1951). For analysis of the American attack on dams during the Korean War, see *The Attack on the Irrigation Dams in North Korea*, 4 AIR UNIV. Q. REV. 40 (Winter 1953-54).

war against another enemy. Causing intentional flooding which would inundate civilians probably would be more roundly condemned by world opinion today than during the 1940's. It is unlike wetting down rioters or muddying trails.

Hazardous Weather Manipulation

A portion of weather modification research in the United States has been directed toward developing techniques for control of weather hazards. In addition to their work on precipitation modification, our scientists have sought to find means to suppress cold fog,[22] warm fog,[23] lightning[24] and hail,[25] and they have conducted experiments on tornadoes[26] and hurricanes.[27] The military has had an understandable interest in these efforts. Ability to alter the impact of severe weather can be of significant advantage to a belligerent.

One of the earliest examples of military efforts to manipulate weather concerned fog. Depending on military posture, the presence of fog in an operational area may be an asset or a liability. Fog obscures movements of men and materiel and masks other potential tar-

22. Beckwith, *Impacts of Weather on the Airline Industry: The Value of Fog Dispersal Programs*, in HUMAN DIMENSIONS OF WEATHER MODIFICATION 195 (W. Sewell ed. 1966); Fletcher, *Operational Applications of Fog Modification*, in PROCEEDINGS OF INT'L CONF. ON WEATHER MODIFICATION, CANBERRA, AUSTRALIA 255 (1971).

23. AIR TRANSPORT ASS'N OF AMERICA, AIRLINE WARM FOG DISPERSAL TEST PROGRAM AT SACRAMENTO, CAL. (1968); Hindman, *Meteorological Conditions Favorable for the Artificial Dissipation of Warm Fog*, in PROCEEDINGS OF THIRD NAT'L CONF. ON WEATHER MODIFICATION 54 (1972); Jiusto, Pilié & Kocmond, *Fog Modification With Giant Hygroscopic Nuclei*, 7 J. APP. METEOR. 860 (1968); MacCready, Jr., *Warm Fog Modification*, 1 J. WEATHER MOD. (WMA) 11 (1969); St.-Amand, Clark, Wright & Finnegan, *Warm Fog Modification*, in PROCEEDINGS OF INT'L CONF. ON WEATHER MODIFICATION, CANBERRA, AUSTRALIA 259 (1971).

24. Fuquay, *Weather Modification and Forest Fires*, 1967 AM. ASS'N ADV. SCI. 309. *See generally* Taylor, *Lightning-Agent of Change in Forest Ecosystems*, 69 J. FORESTRY 477 (1971); Uman, "Everything You Always Wanted to Know About Lightning But were Afraid to Ask," *Saturday Rev.*, May 13, 1972, at 36.

Weather modification has been used to fight forest fires by dampening timber lands as well as by suppressing lightning. Harpster & Douglas, *Weather Modification —A Fire Control Tool*, 3 J. WEATHER MOD. (WMA) 244 (1971).

25. Dennis, *The Theory and Practice of Hail Suppression*, 2 J. WEATHER MOD. (WMA) 147 (1970); Goyer, Howell, Schaefer, Schleusener & Squires, *Project Hailswath*, 47 BULL. AM. METEOR. SOC'Y 805 (1966); Henderson, *An Operational Hail Suppression Program in Kenya*, 1 J. WEATHER MOD. (WMA) 30 (1969); Schickedanz & Changnon, Jr., *The Design and Evaluation of the National Hail Research Experiment in Northeast Colorado*, 3 J. WEATHER MOD. (WMA) 160 (1971); Schleusener, *Lessons from Project Hailswath*, in FIFTH CONF. ON SEVERE LOCAL STORMS 24 (1967); Swinbank, *The National Hail Research Experiment*, in PROCEEDINGS OF THE INT'L CONF. ON WEATHER MODIFICATION, CANBERRA, AUSTRALIA 203 (1971).

26. Henderson & Carley, *The Airborne Seeding of Six Tornadoes*, in PROCEEDINGS OF THIRD NAT'L CONF. ON WEATHER MODIFICATION 241 (1972).

27. Gentry, *Modification Experiments on Hurricane Debbie, August 1969*, in PROCEEDINGS OF SECOND NAT'L CONF. ON WEATHER MODIFICATION 205 (1970). *See also* N.Y. Times, Aug. 18, 1969, at 22, col. 4; Aug. 19, 1969, at 24, col. 6; Aug. 20, 1969, at 27, col. 3; Aug. 21, 1969, at 26, col. 3. On hurricane seeding, see DEP'T OF THE NAVY & ESSA, PROJECT STORMFURY, ANNUAL REPORTS (1965-68) (classified).

gets. Smokescreens have been used as artificial fogs to hide operations on the land and at sea. Fog may also hinder military operation, however, and a great deal of research has been devoted to radar and other electronic means of "seeing through" fog.[28] During the Second World War the Air Force, using the FIDO fog clearing system, was able to operate during some foggy days when otherwise it could not have done so.[29] While there is an obvious military potential in fog manipulation, the reports of military applications of weather changing in Southeast Asia speak primarily of rainmaking.

The Navy has been a partner of the National Oceanic and Atmospheric Administration in hurricane studies and experiments.[30] Weather scientists have not yet developed the capacity to change the direction of such storms, and perhaps they never will. There would be a clear military benefit to be derived from channeling a hurricane or cyclone over unfriendly territory. No one has suggested that we have tinkered with severe tropical storms in Indochina, but several meteorologists have made statements in opposition to such undertakings.[31]

LAW

Recently three legal proposals aimed at banning weather warfare have been under discussion. Senator Gaylord Nelson's rider on the Military Procurement Authorization bill sought to use domestic law to bar use by the United States of weather modification for military purposes. Senator Claiborne Pell has introduced a resolution in the Senate urging the United States government to negotiate treaties which would bind signatory nations to eschew meteorological warfare. The Sierra Club and the Federation of American Scientists have asserted that efforts to increase and control rain for military purposes have violated international law by breaching the Declaration of the United Nations Conference on the Human Environment, adopted in June 1972 at Stockholm. This section will detail the disposition of these three proposals.

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28. L. BATTAN, RADAR OBSERVES THE WEATHER (1962).

29. L. BATTAN, HARVESTING THE CLOUDS: ADVANCES IN WEATHER MODIFICATION 60-61 (1969).

30. For discussion of the international implications of Project Stormfury, the Navy's hurricane modification program, see Davis, *The United States and Mexico: Weather Technology, Water Resources and International Law,* 12 NAT. RES. J. 530 (1972).

31. Walter O. Roberts, director of the National Center for Atmospheric Research and past president of American Association for the Advancement of Science, has stated that "if you could visit a hurricane on somebody, I would be very opposed and consider it very serious." Shapley, *supra* note 12, at 1219.

Domestic Law

There has been very little federal legislation dealing specifically with weather modification. In 1953 a law was enacted creating the Advisory Committee on Weather Control with a charter calling for it to evaluate public and private weather management.[32] In 1957 the National Science Foundation was granted authority to support weather modification research, to obtain information and to report annually to the President and Congress.[33] At first the Foundation gathered data from modifiers who reported on a voluntary basis; then in 1966 it promulgated regulations which required reporting.[34] Congress repealed the Foundation's power to demand reporting in 1968.[35] Late in 1971 President Nixon signed an act which gives the Department of Commerce the power to require reporting.[36] This law, however, does not apply to weather modification activities of agents, independent contractors or employees acting for the federal government.[37] Accordingly there is no existing federal law which requires the military to publicize their weather management activities.[38]

On July 28, 1972, during the Senate debate on the Military Procurement Authorization for the fiscal year 1973, and after the House of Representatives had passed its version of the bill, Senator Gaylord Nelson called up his amendment to the bill and offered to modify the rider so it would read as follows:

> Notwithstanding any other provision of law, none of the funds authorized to be appropriated by this or any other Act may be obligated or expended for the purpose of—
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> (1) weather modification activities as weapons of war;
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> . . . .
>
> (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

32. Act of Aug. 13, 1953, Pub. L. No. 83-256, ch. 426, 67 Stat. 559. The purpose of the evaluation was to determine "the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions." *Id.* at § 3.

33. Act of July 11, 1958, Pub. L. No. 85-510, 72 Stat. 353.

34. 45 C.F.R. §§ 635.1-.7 (1968).

35. Act of July 18, 1968, Pub. L. No. 90-407, § 11, 82 Stat. 360.

36. 15 U.S.C.A. §§ 330-30e (Supp. Apr. 1972). The Department of Commerce rules are set forth at 37 *Fed. Reg.* 22,974 (1972).

37. 15 U.S.C.A. § 330(2) (Supp. Apr. 1972).

38. Like almost all federal bills on the subject, the "Weather Modification and Precipitation Management Act of 1972," S. 3515, 92d Cong., 2d Sess. (1972), proposed by Senator Bellman, has not been enacted. For discussion of efforts to obtain federal statutes controlling rainmaking, see Johnson, *Federal Organization for Control of Weather Modification*, 10 NAT. RES. J. 222, 235-52 (1970).

> (4) procuring or maintaining agents, delivery systems, or dissemination equipment for the purpose of modifying weather conditions for military purposes . . . .[39]

While a majority of the states have some type of legislation regulating weather modification activities[40] with reporting and licensing requirements as common features of the laws,[41] Maryland is the only state that went further and banned weather modification completely.[42] The Nelson rider to the appropriations authorization was intended to follow the Maryland position and bar the military use of weather modification. In his remarks supporting the amendment, the Senator lambasted the military for use of environmental warfare in Indochina. The ban he proposed included prohibiting the use of so-called "fire storms,"[43] and his criticism extended to defoliation[44] as well as weather modification.

Senator Stennis, who was managing the appropriations bill, accepted the amendment and it was adopted without further discussion and without dissent.[45] This created concern among Department of Defense weather researchers,[46] but they were assured by their superiors that the rider would be killed in conference.[47] The assurance was well-founded. When the procurement bill came back to the House of Representatives from the conference committee in September, it was accompanied by a report which noted:

> The House conferees pointed out that no consideration to such a provision was given in the House and time was not available for

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39. 118 CONG. REC. 12,186 (daily ed. July 28, 1972).

40. For a discussion of state weather modification laws, see Davis, *State Regulation of Weather Modification*, 12 ARIZ. L. REV. 35 (1970).

41. *See* R. DAVIS, LEGAL GUIDELINES FOR ATMOSPHERIC WATER RESOURCES MANAGEMENT § 2 (1968).

42. MD. ANN. CODE art. 66C, § 110A (1970). This provision expired on September 1, 1971. The 1972 supplement to the Maryland Code does not contain any reenactment of the law.

43. 118 CONG. REC. 12,186 (daily ed. July 28, 1972). For discussion of the use of fire storms in Vietnam, see Shapley, *Technology in Vietnam: Fire Storm Project Fizzled Out*, 177 SCI. 239 (1972). "Fire storm" is used by Defense Department planners to describe the holocausts at Hamburg and Dresden during World War II. *Id.*

44. 118 CONG. REC. 12,187, 90-95 (daily ed. July 28, 1972). Probably the most widely circulated discussion on American defoliation efforts is T. WHITESIDE, THE WITHERING RAIN: AMERICA'S HERBICIDAL FOLLY (1971). A far less circulated study was ARMY CORPS OF ENGINEERS STRATEGIC STUDIES GROUP, HERBICIDES AND MILITARY OPERATIONS (1972) (3 vols.) (classified). *See generally* McConnell, *Mission: Ranch Hand*, AIR UNIV. REV. 89 (Jan.-Feb. 1970).

Herbicidal warfare has been analyzed in Flamm & Cravens, *Effects of War Damage On the Forest Resources of South Vietnam*, 69 J. FORESTRY 784 (1971); Shapley, *Herbicides: DOD Study of Viet Use Damns with Faint Praise*, 177 SCI. 776 (1972); Westing, *Forestry and the War In South Vietnam*, 69 J. FORESTRY 777 (1971).

45. 118 CONG. REC. 12,195 (daily ed. July 28, 1972).

46. *See* text accompanying notes 142-46 *infra*.

47. Telephone interview with Pierre St.-Amand, Director of the Earth and Planetary Sciences Division, Naval Weapons Center, China Lake, California, Aug. 21, 1972.

> the House conferees to gather sufficient information to evaluate the effect such an amendment might have on the operations of the Department of Defense. In addition, it was learned that the subject is being addressed in hearings in another committee of the Congress.
>
> The Senate, therefore, recedes.[48]

The bill was passed and signed into law without the Nelson amendment.[49]

There are those who are convinced that the Maryland total ban on weather modification had been violated, but no one was ever caught attempting to carry on illegal rainmaking in that state.[50] Enforcement of a total bar is not a simple undertaking. Neither would be enforcement of a prohibition upon spending money for buying equipment and materiel and for giving instructions in the military application of weather modification techniques. According to one writer, "[w]hether the military has used weather modification in Indochina has been remarkably difficult to prove. Presumably, proof will be equally elusive in the future to lawmakers tracking down alleged violations."[51]

Proof of use will be a key factor in a lawsuit which was filed on September 8, 1972, in the Court of Claims against the United States by Weather Engineering Corporation of Canada, Ltd., and Weather Engineering Corporation of America, its subsidiary in the United States.[52] According to the president of the company, Bernard Power, a rainmaking device which he invented and patented may have been used by the United States in Vietnam. The apparatus, called Weathercord, is ejected from an aircraft flying over an area to be treated. It falls into the clouds, explodes and releases silver iodide crystals, which "seed" the cloud by acting as artificial nuclei on which drops of precipitation form.[53]

The allegations tending to support the claim of use of Weathercord in Vietnam assert that the device was demonstrated in the presence of American military observers in Newfoundland in 1966. Thereafter

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48. 118 CONG. REC. 8187 (daily ed. Sept. 11, 1972); H.R. REP. No. 92-1388, 92d Cong., 2d Sess.—(1972).
49. Act of Sept. 26, 1972, Pub. L. No. 92-436.
50. Freed, *Putting in the Weather Fix*, 215 THE NATION 499 (1972).
51. Shapley, *Senate Bans Use of Weather, Fire as Weapons by DOD*, 177 SCI. 499 (1972).
52. Weather Eng'r Corp. of America v. United States, No. 343-72 (Ct. Cl., filed Sept. 8, 1972), *discussed*, N.Y. Times, Oct. 4, 1972, at 8, col. 1.
53. Patent Nos. 3,046,168 (July 24, 1962), 3,127,107 (Mar. 31, 1964) & 3,441,214 (Apr. 29, 1969). For analysis of the effectiveness of Weathercord as a cloud seeding device, see Goyer, Grant & Henderson, *The Laboratory and Field Evaluation of Weathercord, A High Output Cloud Seeding Device*, in 5 J. APPLIED METEOR. 211-16 (1966).

Mr. Power and his Washington representative met with a White House military aid, showed him the apparatus and discussed how it could be used in the war. Power alleges that he was then told "that the United States would either get in touch with them for a supply of the devices, use them without telling the company or do nothing."[54] Apparently he heard nothing. After reading the Jack Anderson column, Mr. Power attempted to ascertain if Weathercord had been used in Vietnam. The Defense Department did not supply him with any information as to what they had used in the weather modification program.[55]

When the case comes to trial the claim will be difficult to sustain. It will be necessary to prove that there has been weather modification in Vietnam, that his devices were used or that equipment using their principle was employed and the extent to which they were in fact employed. The Department of Defense has available an array of weather modification ordnance developed by its scientists, all of which is considerably more sophisticated than the explosive device which Powers mentions in his complaint.[56] Equipment developed by the Defense Department is widely used for civilian operations both in the United States and abroad.[57] Proof of use of Weathercord will be a tall order.

Treaty Limitations

Weather modification achieved its present scientific respectability largely as the result of a 1966 report prepared for the National Academy of Sciences by a Special Panel on Weather and Climate Modifica-

54. N.Y. Times, Oct. 4, 1972, at 8, col. 1. The claim filed is for $95 million. This figure is an estimate of profits lost by the Weather Engineering Corporation. Mr. Power estimated that 1.9 million of his devices would have been used in a weather modification program over an area the size of the Ho Chi Minh trail network during the monsoon seasons between 1967 and 1972. *Id.*

55. The plaintiffs have filed a petition pending a motion for discovery under Rule 36 and also, on October 10, 1972, have filed an amended petition pending a motion for discovery under Rule 36. In the latter, they assert that they "require documents and other information specifically identifying the procedures and structures used in the weather modification program to determine the scope of infringement." Weather Eng'r Corp. of America v. United States, No. 343-72 (Ct. Cl., filed Oct. 10, 1972) (Amended Petition Pending Motion for Discovery Under Rule 36), at ¶ 15. *See also id.* at ¶ 16.

56. In fact, tests on Weathercord have been discouraged for reasons of aircraft safety. *See* St.-Amand, Memorandum, Comments on Patent No. 3,127,107, Dept. of Navy, Naval Weapons Center, China Lake, Calif. (Nov. 8, 1972). It was concluded in this memorandum that no one in the Department of Defense has ever used Weathercord in weather modification. *Id.* ¶ 8.

57. Some of the contributions by the Navy are discussed in St.-Amand, Burkardt, Finnegan, Donnan & Jorgensen, *Pyrotechnic Production of Nucleants for Cloud Modification - Part I—General Principles*, 2 J. WEATHER MOD. (WMA) 25 (1970); St.-Amand, Burkardt, Finnegan, Wilson, Elliott & Jorgensen, *Pyrotechnic Production of Nucleants for Cloud Modification - Part II—Pyrotechnic Compounds and Delivery Systems for Freezing Nucleants*, 2 J. WEATHER MOD. (WMA) 33 (1970); Vetter, Finnegan, Burkhardt, St.-Amand, Sampson & Kaufman, *Pyrotechnic Production of Nucleants for Cloud Modification - Part III—Propellant Compositions for Generation of Silver Iodide*, 2 J. WEATHER MOD. (WMA) 53 (1970).

tion which was chaired by Gordon J. F. MacDonald.[58] Dr. MacDonald was a member of President Johnson's Science Advisory Committee, and more recently has been a member of the Council on Environmental Quality. He contributed to a volume published in 1968 under the title *Unless Peace Comes*.[59] In his chapter entitled "How to Wreck the Environment," Dr. MacDonald advanced the thesis that environmental and geophysical manipulation might become terrifyingly practical as weapons systems. Among the subjects discussed were weather, climate, earthquake and ocean modification.[60] According to MacDonald, "[t]he 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."[61] The potential physical effects of deliberate environmental modification are so great and give rise to such complex political, legal, economic and sociological consequences that MacDonald suggested "that perhaps all our present involvements in nuclear affairs will seem simple."[62]

On March 17, 1972, Senator Claiborne Pell and 13 other senators submitted a resolution to the United States Senate stating that the government of this country "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 . . . ."[63] The term "environmental or geophysical modification activity" is defined in the proposed treaty to include weather, climate, earthquake and ocean modification.[64] Senator Pell would have the administration excise MacDonald's nightmare. The United States would take the lead in convincing the nations of the world not to disturb the environment by use of geophysical and environmental warfare.

The Pell proposal was referred to the Senate Committee on Foreign Relations. The Subcommittee on Oceans and International Environment, chaired by Senator Pell, conducted hearings on the resolu-

58. PANEL ON WEATHER AND CLIMATE MODIFICATION, NATIONAL ACADEMY OF SCIENCE, WEATHER AND CLIMATE MODIFICATION (1965) (2 vols.).

For other official reports on weather modification, see ADVISORY COMMITTEE ON WEATHER CONTROL, FINAL REPORT (1957) (2 vols.); D. GILMAN, J. HIBBS & P. LASKIN WEATHER AND CLIMATE MODIFICATION (Report to the Chief, U.S. Weather Bureau) (1965); L. HARTMAN, WEATHER MODIFICATION AND CONTROL, S. REP. NO. 1139, 89th Cong., 2d Sess. (1966); J. LACKNER, PRECIPITATION MODIFICATION (Report for U.S. Nat'l Water Comm'n) (1971); SPECIAL COMMISSION ON WEATHER MODIFICATION, WEATHER AND CLIMATE MODIFICATION (Report to National Science Foundation) (1965).

59. MacDonald, *How to Wreck the Environment*, in UNLESS PEACE COMES 181 (N. Calder ed. 1968). The book has a series of chapters prepared by scientists in which they look at the military potential of various scientific advances.

60. *Id.* at 183-98.

61. *Id.* at 183.

62. *Id.* at 204.

63. S. Res. 281, 92d Cong., 2d Sess. (1972).

64. *Id.* at art. II.

tion on July 26 and 27, 1972.[65] One of the five government witnesses at these hearings was Gordon MacDonald, present as a representative of the Council on Environmental Quality. MacDonald and his government colleagues opposed the geophysical warfare ban treaty.[66] Their position was that halting research, experimentation and use of environmental modification as a weapon might delay its development for peaceful purposes. MacDonald did indicate, however, that no major weather modification project should be undertaken unless the results are reasonably forseeable.[67] Several non-governmental scientists went beyond this note of caution in their testimony and spoke in favor of the resolution.[68] From the testimony of the government witnesses, however, it is obvious that the Nixon administration will not seek a treaty limitation upon military rainmaking and other environmental warfare.

The United States has had considerable success in the negotiation of arms limitation treaties similar in some respects to Pell's proposal. One type of treaty limits the introduction of certain types of weapons into environments which have only recently become readily accessible. In this category are the Antarctic Treaty, the Outer Space Treaty and the Seabed Treaty. Non-militarization of Antarctica is the goal of the Antarctic Treaty.[69] Among other things, it prohibits any measures of a military nature on the continent[70] and specifically bans nuclear explosions.[71] The Outer Space Treaty reserves the moon and other celestial bodies for peaceful purposes[72] and bars the placing in orbit or stationing in outer space of weapons of mass destruction.[73] The Seabed Treaty prohibits placing weapons of mass destruction and their delivery systems on the seabed beyond a 12-mile zone contiguous to the coast.[74] These treaties aim to protect environments made accessible by

65. *Hearings, supra* note 4. *See also* 118 CONG. REC. 824 (daily ed. July 26, 1972); 118 CONG. REC. 831 (daily ed. July 27, 1972).

66. *Hearings, supra* note 4, at 17-53, 62-80. *See also* Shapley, *Science Officials Bow to Military on Weather Modification*, 177 SCI. 411 (1972).

67. *Hearings, supra* note 4, at 73.

68. *Id.* at 80-81.

69. The Antarctic Treaty, Dec. 1, 1959, [1961] 12 U.S.T. 794, 402 U.N.T.S. 71 (effective June 23, 1961). For an analysis of this treaty, see H. TAUBENFELD, A TREATY FOR ANTARCTICA (Internat'l Conciliation, No. 531) (1961).

70. The Antarctic Treaty, Dec. 1, 1959, art. I, [1961] 12 U.S.T. 795, 402 U.N.T.S. 72 (effective June 23, 1961). *See also id.* art. IX(1)(A), [1961] 12 U.S.T. 798, 402 U.N.T.S. 78.

71. *Id.* art. V(1), [1961] 12 U.S.T. 796, 402 U.N.T.S. 76.

72. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, art. IV, [1967] 18 U.S.T. 2413, 610 U.N.T.S. 208; *see* Gotlieb, *Nuclear Weapons in Outer Space*, 3 CAN. Y.B. INT'L L. 3 (1965).

73. Treaty, *supra* note 72.

74. Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-bed and on the Ocean Floor and in the Subsoil Thereof, art. I(1). The text of this treaty is in U.S. ARMS CONTROL AND

new technology; the Pell treaty seeks to protect the environment which is endangered by military application of a new technology. Both instances involve technology and both are related to the environment.

Another type of arms limitation treaty is designed to reduce the dangers to the world that derive from testing,[75] proliferation[76] and maintaining nuclear weapons.[77] There is notable similarity between the functions of such treaties and those underlying the Pell proposals. The atomic and hydrogen bombs have not been outlawed by treaty; but some of the risk inherent in their availability has been minimized. The weather modification treaty proposal would constitute a test ban. Parties to the treaty would be barred from conducting "any research or experimentation relating to the development of any [environmental or geophysical modification] activity as a weapon of war."[78] The Pell resolution also contains an antiproliferation section. Signatory nations "undertake not to assist, encourage or induce any State to carry out [environmental or geophysical modification] activities" as a weapon of war "and not to participate in any other way in such actions."[79] It goes beyond the Strategic Arms Limitation Talks agreements which seek to control the maintenance of certain types of nuclear weapons. The proposed treaty prohibits use of weather modification as a weapon.[80] In that respect the Senator's recommendation does break new ground as an arms limitation measure.

The Pell resolution would appear to present a promising opportunity for negotiation of treaty arrangements which would promote international cooperation and reduce potential risks to the environment. Our government has been able to reach other weapons system restric-

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DISARMAMENT AGENCY, 10TH ANNUAL REPORT TO CONGRESS 37 (1971), and is discussed in Stein, *Legal Restraints in Modern Arms Control Agreements*, 66 AM. J. INT'L L. 255, 264-67 (1972).

75. Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, Aug. 5, 1963, [1963] 14 U.S.T. 1313, T.I.A.S. No. 5433, 480 U.N.T.S. 43 (effective Oct. 10, 1963). The background of the treaty is set forth in H. JACOBSON & E. STEIN, DIPLOMATS, SCIENTISTS, AND POLITICIANS: THE UNITED STATES AND THE NUCLEAR TEST BAN NEGOTIATIONS (1966).

76. Treaty on the Non-Proliferation of Nuclear Weapons, July 1, 1968, [1970] 21 U.S.T. 483, T.I.A.S. No. 6839 (effective March 5, 1970); *see* Firmage, *The Treaty on the Non-Proliferation of Nuclear Weapons*, 63 AM. J. INT'L L. 711 (1969).

77. The Senate has approved an antiballistic missile treaty negotiated at the Strategic Arms Limitation Talks and signed by President Nixon during his May 1972 visit to Moscow. 118 CONG. REC. 14,913 (daily ed. Sept. 14, 1972). Both houses of Congress have approved and the President has signed the congressional resolution endorsing the five-year freeze at present levels of most United States and Russian offensive nuclear weapons. N.Y. Times, Oct. 1, 1972, at 10, col. 1. This interim agreement was also a product of the SALT negotiations and of the Moscow summit meeting. Earlier efforts in the Strategic Arms Limitation Talks are the subject of Bunn, *Missile Limitation: By Treaty or Otherwise?*, 70 COLUM. L. REV. 1 (1970).

78. S. RES. 281, 92d Cong., 2d Sess. art. I(2) (1972).

79. *Id.* art. I(3).

80. *Id.* art. I(1).

tion agreements. These precedents are not so different in kind from the type of treaty that would reserve weather modification for peaceful purposes as to make the Pell proposal a sharp departure from our historical approach to arms limitation. Such a treaty would be quite consistent with the posture of our diplomacy of the last quarter century.

International Conventions, Customs and Principles

A week before the hearings were held on the resolution offered by Senator Pell, the Sierra Club and the Federation of American Scientists wrote President Nixon asking him to halt immediately the use of weather modification as a weapon and requesting that environmental and geophysical research be devoted solely to peaceful uses. In their communication the organizations asserted that weather warfare "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."[81] They further expressed the belief that our conduct "raises serious question[s] as to our good faith in entering into this solemn compact and our intention to abide by it."[82]

The document referred to by the two groups was intended as a guide for an international fight on pollution. It was adopted in Stockholm by the representatives of nations having 90 percent of the world's population, and will be presented to the 1972-73 session of the United Nations General Assembly for ratification. Although the program and the principles of the declaration are voluntary, they do provide a set of guidelines against which world opinion can measure future environmental actions.[83]

The Declaration asserts that signatory states should enter into bilateral and multilateral agreements to deal with adverse transnational environmental effects.[84] The treaty proposed by Senator Pell would be an example of compliance with this principle. The United Nations Conference on the Human Environment also urged cooperation among nations to develop further the international law regarding compensation for environmental damage caused in other countries.[85] Although legal scholars have suggested that analogous principles of international

81. Letter from Sierra Club and Federation of American Scientists to President Richard M. Nixon, July 20, 1972.
82. *Id.*
83. N.Y. Times, June 17, 1972, at 1, col. 8; at 2, col. 3. *See also* Hawkes, *Stockholm: Politicking, Confusion, but Some Agreements Reached*, 176 SCI. 1308 (1972).
84. For a text of the principles, see N.Y. Times, June 17, 1972, at 2, col. 3. The principle on agreements is No. 24.
85. *Id.* principle No. 22.

law might be made applicable to cases involving international impact by weather modification,[86] thus far no claims for losses have been asserted and no treaty provisions deal with losses caused by weather management.

In their letter to the President, the Sierra Club and the Federation of American Scientists quoted from Principle Number Twenty-one adopted by the conference. It states:

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to insure 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.[87]

This principle, they argued, would be violated by continued artificial rainmaking by the military as a weapon in the Southeast Asian war.[88]

Press accounts of the role of meteorology in Indochina do not depict it as benign like Cellini's cloud cannonade nor informational as it was in World War Two. Rather rainmaking under our control was intended to "cause damage to the environment of other states."[89] Assuming that the allegation is true, our responsibility not to cause such damage is conditioned by the phrase "in accordance with the Charter of the United Nations and the principles of international law."[90] It is instructive to see what they have to say of weaponry and the extent

86. For articles dealing with weather modification and international law, see Corbridge, Jr. & Moses, *Weather Modification: Law and Administration*, 8 NAT. RES. J. 207 (1968); Davis, *The United States and Mexico: Weather Technology, Water Resources and International Law*, 12 NAT. RES. J. 530 (1972); Goldie, *Science, Policy and the Developing Frontiers of International Law*, 4 AKRON L. REV. 114, 116 (1971); Hassett, *Weather Modification and Control: International Organization Prospects*, 7 TEXAS INT'L L.J. 89 (1971); Oppenheimer & Lambright, *Technology Assessment and Weather Modification*, 45 So. CALIF. L. REV. 570 (1972); Samuels, *Prospective International Control of Weather Modification Activities*, 21 U. TORONTO L.J. 222 (1971); Taubenfeld, *Weather Modification and Control: Some International Legal Implications*, 55 CALIF. L. REV. 493 (1967). *See also* R. DAVIS, THE LEGAL IMPLICATIONS OF ATMOSPHERIC WATER RESOURCES DEVELOPMENT AND MANAGEMENT §§ 14.1-15.2 (1968); T. Malone, *Current Developments in the Atmospheric Sciences and Some of their Implications for Foreign Policy*, paper presented at Joint Meeting of the Policy Planning Council, Dep't State and Special Panel of Comm. on Science and Public Policy, Nat'l Academy of Sciences, Washington, D.C. (1968); Moses & Corbridge, *Legal Structures for International Supervision of Weather Modification Techniques* (Int'l Conf. on Water for Peace Paper No. P/635, 1967); Taubenfeld, *The International Lawyer and Weather Modification*, in HUMAN DIMENSIONS OF THE ATMOSPHERE 99 (W. Sewell ed. 1968); Taubenfeld & Taubenfeld, *The Law and Weather Modification*, in PROCEEDINGS OF FIRST NAT'L CONF. ON WEATHER MODIFICATION 190 (1968); Weiss, *The International Legal and Political Implications of Weather Modification*, in PROCEEDINGS OF THIRD NAT'L CONF. ON WEATHER MODIFICATION 232 (1972).

87. N.Y. Times, June 17, 1972, at 2, col. 5.

88. Letter, *supra* note 81.

89. N.Y. Times, June 17, 1972, at 2, col. 5; *quoting* principle No. 21.

90. *Id.*

to which any such provisions apply to use of cloud treatment as a weapons system.

The Charter of the United Nations does not regulate national armaments. It does, however, empower the General Assembly to consider "the general principles of cooperation in the maintenance of international peace and security, including the principles governing disarmament and the regulation of armaments."[91] The Charter also directs the Security Council to formulate plans "for the establishment of a system for the regulation of armaments."[92] Acting under these provisions agencies of the United Nations have wrestled with general arms reduction proposals and with specific suggestions relating to atomic, biological and chemical weapons.[93] None of the suggestions for banning certain types of weapons deal with weather modification.

International agreements relating to weapons systems include the Declaration of St. Petersburg of 1868,[94] the Declarations and Conventions of the Hague Peace Conferences of 1899 and 1907,[95] and the Geneva Protocol of 1925 which resulted from a conference in Geneva called by the League of Nations.[96] The United States was not a party to the St. Petersburg Declaration and did not ratify the Geneva Protocol, but has adhered to Hague Convention No. IV[97] and ratification of the Geneva Protocol is under consideration.[98] None of these undertakings deal with weather modification.

Custom, as well as treaties, is a source of international law. For international custom to become the source of an international norm, it must meet two prerequisites: "(1) usage or practice among states coupled with (2) the conviction that the practice is applied because it is legally binding."[99] So far the United States is the only country

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91. U.N. CHARTER art. 11, para. 1.
92. *Id.* at art. 26.
93. L. GOODRICH, E. HAMBRO & A. SIMONS, CHARTER OF THE UNITED NATIONS: COMMENTARY AND DOCUMENTS 118-25, 211-15 (3d ed. 1969); L. GOODRICH, THE UNITED NATIONS 218-41 (1959).
94. For the text of the Declaration, see J. SCOTT, DOCUMENTS RELATING TO THE PROGRAM OF THE FIRST HAGUE PEACE CONFERENCE 30 (1921).
95. The results of the Hague Conferences are described in W. HULL, THE TWO HAGUE CONFERENCES AND THEIR CONTRIBUTION TO INTERNATIONAL LAW (1908).
96. Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, 25 AM. J. INT'L SUPP. 94 (1931).
97. Hague Convention No. IV, Respecting the Laws and Customs of War on Land, Oct. 18, 1907, 36 Stat. 2277 (1910), T.S. No. 539 (effective Feb. 28, 1910).
98. *See* Baxter & Buergenthal, *Legal Aspects of the Geneva Protocol of 1925*, 64 J. INT'L L. 853 (1970); Bunn, *Banning Poison Gas and Germ Warfare: Should the United States Agree?*, 1969 WISC. L. REV. 375; Moore, *Ratification of the Geneva Protocol on Gas and Bacteriological Warfare: A Legal and Political Analysis*, 58 VA. L. REV. 419 (1972).
99. A. THOMAS & A. THOMAS, JR., LEGAL LIMITS ON THE USE OF CHEMICAL AND BIOLOGICAL WEAPONS 135 (1970). *See also* H. KELSEN, PRINCIPLES OF INTERNATIONAL LAW 440 (2d ed. 1966).

alleged to have used weather modification in a hostile manner. This general abstention, though, can be explained by the lack of technology or opportunity of other nations. Their conduct is not motivated by a feeling that some sanction ought to be imposed upon a user of meteorological weaponry.[100] The International Court of Justice has stated that "only if such abstention were based on their being conscious of having a duty to abstain would it be possible to speak of an international custom."[101]

General principles of warfare recognized by civilized nations also serve as a source of international legal principles. One basic principle of warfare is the military necessity doctrine allowing commanders to use any type of weapons system, except those outlawed by the law of war, to further the legitimate belligerent objective of overpowering the enemy.[102] The military necessity doctrine is conditioned by the principle of humanity and the doctrine of proportionality. Considerations of humanity ban wanton destruction of property and infliction of human suffering not needed to achieve a military victory.[103] Weapons systems can be used only at times and under circumstances when they inflict harm which is not disproportionate to the military end sought. The level of destruction must be commensurate with the military utility of the weapon. This standard implies that the user must have some ability to control the weapon.[104]

It is unclear whether the Sierra Club and the Federation of American Scientists considered the doctrine of proportionality in making their appeal to the government to stop use of weather modification as a weapon of war in Indochina. They stated: "We believe that such

100. Although there are over two dozen nations where weather modification experiments or operating projects have been conducted or contemplated, the main centers for research have been in Australia, Russia and the United States. Only the United States has been in a military situation where there was occason to use weather warfare. The Australian program is discussed in Davis, *The Law of Precipitation Enhancement in Victoria*, 7 LAND & WATER L. REV. 1 (1972). The Russian involvement with weather management is discussed in text accompanying note 150 *infra*.

101. Case of the S.S. "Lotus" [1927] P.C.I.J., ser. A, No. 9, at 28, *discussed*, Hudson, *The Sixth Year of the Permanent Court of International Justice*, 22 AM. J. INT'L L. 1, 8-14 (1928).

102. O'Brien, *The Meaning of "Military Necessity" in International Law*, 1 WORLD POLITY 109 (1957).

103. A. THOMAS & A. THOMAS, JR., *supra* note 99, at 193-94.

104. Mallison, Jr., *The Laws of War and the Juridical Control of Weapons of Mass Destruction in General and Limited Wars*, 36 GEO. WASH. L. REV. 308, 342 (1967).

For views on the legality of the use of atomic, biological and chemical weaponry, see Bright, Jr., *Nuclear Weapons As A Lawful Means of Warfare*, 30 MILITARY L. REV. 1 (1965); CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE, THE CONTROL OF CHEMICAL AND BIOLOGICAL WEAPONS (1971); N. SINGH, NUCLEAR WEAPONS AND INTERNATIONAL LAW (1959); A. THOMAS & A. THOMAS, JR., *supra* note 99; U.S. DEP'T OF THE ARMY, THE LAW OF LAND WARFARE (FIELD MANUAL 27-10), at ch. 2, § III (1956).

environmental modification activities can have significant unforeseen consequences with widespread and perhaps uncontrollable damage."[105] This assertion raises issues of fact and questions of policy concerning the physical aspects of weather warfare. If weather modification is uncontrollable, it may be disproportionate and hence violate a principle of international law. Furthermore, if American weather management in Southeast Asia has also wrought damage to the environment, this nation has failed to adhere to the guidelines in the Stockholm Declaration. That Declaration has strong moral, if not legal, backing and our failure to comply with it should at least embarrass the United States. On the other hand, if weather modification is not uncontrollable, has not been used to inflict wanton destruction and unnecessary suffering, and has been employed as one means of overpowering the enemy, conduct by the American military has neither violated principles of international law nor contravened the Stockholm Declaration.

POLICY

In order to evaluate whether the three legal proposals discussed above are appropriate, considerations of policy must be examined. The examination must include the use of weather modification capabilities as a hostile weapon, as well as the possible results from banning such use. The physical aspects of weather management, scientific considerations and international relationships all have a bearing upon policy decisions. Efforts to influence the weather will be judged on their own merits, not in the context of larger questions concerning the legitimacy of the Vietnam War in particular nor the morality of war in general.

Physical Aspects

The most common method used to modify the weather is to seed clouds by introducing glaconic agents that cause liquid water to freeze at warmer temperatures than it would in unseeded clouds. Upon freezing, the liquid water releases heat which in turn causes the parcel of air containing the newly-formed ice to rise. This promotes cloud growth. The fact that water condenses upon ice faster than it does on liquid particles also helps the seeded cloud to grow. The precipitation efficiency of nature is enhanced by the seeding. As the ice crystals grow, they fall, collide and coalesce with water droplets and become

105. Letter, *supra* note 81.

large enough to reach the ground before they evaporate. The process of condensation, collision and coalescence continues throughout the life of the cloud.[106]

Silver iodide is the most widely used glaconic agent. Its effectiveness in serving as nuclei for raindrops depends upon placing the right amount, at the correct time, in the proper place in the cloud. Over the past quarter of a century there has developed considerable knowledge and experience in silver iodide seeding in the United States and abroad. Meteorologists believe that when skillfully used under the right circumstances artificial nucleation is an effective weather management device.[107]

Evaluation of the effectiveness and consequences of the use of weather modification as a weapon is difficult. The major problem is that there is no assurance of what the weather would have been but for the cloud seeding. Experiments in the United States and elsewhere designed to measure the effectiveness of different seeding agents, techniques and delivery systems depend upon using control areas, seeding target areas on a random basis and then comparing with historical data the precipitation data acquired from extensive networks of precipitation gauges in both the target and control areas.[108] It is unlikely that in a military operation separate target and control areas would be established. Seeding flights also would not be limited to days provided by a random numbers table. Rain gauges are probably not present in sufficient quantity and ground instruments in communist occupied territory would probably not be available to the United States. Therefore no determination can be made as to the military efficiency of weather alteration efforts by the usual methods available to meteorologists.

If the military has experimented with weather weaponry for as long as published accounts indicate, results must have been encouraging

106. Cloud formation is described in H. BYERS, ELEMENTS OF CLOUD PHYSICS (1965); R. FLEAGLE & J. BUSINGER, AN INTRODUCTION TO ATMOSPHERIC PHYSICS 79-109 (1963); F. HARE, THE RESTLESS ATMOSPHERE 31-38 (Rev. ed. 1966).

The ice crystal process of natural precipitation formation is examined in J. DAY & G. STERNES, CLIMATE AND WEATHER 217-57 (1970); S. PETTERSSEN, INTRODUCTION TO METEOROLOGY 65-66 (1958). *See generally* N. FLETCHER, THE PHYSICS OF RAINCLOUDS (1966).

For a discussion of cloud seeding in terminology comprehensible to laymen, see L. BATTAN, HARVESTING THE CLOUDS: ADVANCES IN WEATHER MODIFICATION (1969). *See also* L. BATTAN, CLOUD PHYSICS AND CLOUD SEEDING (1962); B. MASON, CLOUDS, RAIN AND RAINMAKING (1962).

107. *See* American Meteorological Society, *Statement on Weather and Climate Modification* (1967), in PROCEEDINGS OF FIRST NAT'L CONF. ON WEATHER MODIFICATION ii-iv (1968); I. Gutmanis & R. Gillis, *Weather Modification: Programs and Prospects*, 2 ENVIRONMENT REP., Monograph No. 8, 3-4 (1971). *See also* the official reports cited in note 53 *supra*.

108. For an illustration of the design of an experimental project, see OFFICE OF ATMOSPHERIC WATER RESOURCES, U.S. DEP'T OF THE INTERIOR, PROJECT SKYWATER PROCEEDINGS: SKYWATER CONFERENCE V (1969).

enough to keep the practice going. Visual observation of precipitation and comparisons of seeded with unseeded clouds probably gave a good indication of what was happening. The monsoons, with a nudge from the rainmakers, hampered enemy logistics. Just what could be ascribed to the nudge and what was provided by nature cannot be known.[109]

Apart from its intended effect of altering precipitation, weather modification also has ancillary effects. These too are difficult to measure. For example, increased precipitation may adversely affect plant life. Experiments in the United States indicate that under appropriate conditions and by correct seeding, precipitation can be increased from 15 to 20 percent from certain cloud types.[110] That increase, though, is within the normal yearly variation. Plant communities can survive such natural variation. Only by careful ecological monitoring over a period of time will it be possible to speak with any assurance about the impact of weather modification on the ecology.[111] Fears of possible ecological disaster from weather management[112] might be well-founded, but it should be borne in mind that there is as yet no evidence of any serious deleterious impact.[113]

109. Statisticians have questioned the success of seeding in Arizona. *See, e.g.*, Neyman, Osborn, Scott & Wells, *Evaluation of the Arizona Cloud-Seeding Experiment*, 69 PROC. NAT'L ACAD. SCI. 1348 (1972); Osborn, *Comments by A Hydrologic Engineer on Cloud Seeding In Arizona*, in PROCEEDINGS OF THIRD NAT'L CONF. ON WEATHER MODIFICATION 146 (1972). The effectiveness of the seeding in Project Whitetop in Missouri has also been questioned by statisticians. Lovasich, Neyman, Scott & Smith, *Wind Directions Aloft and Effects of Seeding on Precipitation in the Whitetop Experiment*, 38 INT'L STATISTICAL INST. REV. 155 (1970); Lovasich, Neyman, Scott & Smith, *Statistical Aspects of Rainfall Stimulation—Problems and Prospects*, 64 PROC. NAT'L ACAD. SCI. 810 (1967).

110. *See* reports cited note 58 *supra*.

111. For a study of the potential ecological impact of the snowpack augmentation pilot project in the San Juan Mountains of Colorado sponsored by the Bureau of Reclamation, see Teller, *Current Studies In the Ecological Effects of Weather Modification in Colorado*, in PROCEEDINGS OF THIRD NAT'L CONF. ON WEATHER MODIFICATION 226 (1972); Weisbecker, TECHNOLOGY ASSESSMENT OF WINTER OROGRAPHIC SNOWPACK AUGMENTATION IN THE UPPER COLORADO RIVER BASIN 299-346 (Stanford Research Institute, 1972).

Ecology and weather modification are considered by C. COOPER & W. JOLLY, ECOLOGICAL EFFECTS OF WEATHER MODIFICATION: A PROBLEM ANALYSIS (Report to Bureau of Reclamation, May 1969); Ecological Soc'y of America, Ad Hoc Weather Working Group, *Biological Aspects of Weather Modification*, 47 BULL. ECOL. SOC'Y AM. 39 (1966); Rango, *Possible Environmental Response to Weather Modification*, in PROCEEDING OF SECOND NAT'L CONF. ON WEATHER MODIFICATION 411 (1970).

112. *E.g.*, 118 CONG. REC. 12,187 (daily ed. July 28, 1972) (remarks of Senator Nelson); *The Spector of Meteorological Warfare*, 102 SCI. NEWS 35 (1972) (Senator Pell); Letter, *supra* note 81.

113. Doubts have been expressed as to what results, if any, followed weather modification activities in Southeast Asia. *See, e.g.*, Purrett, *Weather Modification As A Future Weapon*, 101 SCI. NEWS 254 (1972); Shapley, *Rainmaking: Rumored Use Over Laos Alarms Arms Experts, Scientists*, 176 SCI. 1216 (1972).

In Seymour Hersh's article one government official was quoted as stating: "This kind of thing was a bomb, and Henry [Kissinger] restricted information about it to those who had to know." Another government source said that a group was "now evaluating the program to see how much additional rain was caused." N.Y. Times, July 3, 1972, at 2, col. 8.

Artificial rainmaking also has a human dimension since weather plays an important role in human behavior. There is some literature on climate and psychology[114] and even more on the influence of varying climatic factors on human physiology.[115] Both sociologists[116] and economists[117] have looked at the potential impact of weather modification upon human beings. These human impacts, as well as the other ancillary effects of weather alteration, are again difficult to assess.

Opponents of military utilization of weather management have also mentioned the difficulty of controlling the effects of cloud seeding.[118] Given the problems in determining the impact of artificial rainmaking on precipitation, the ecology and human beings, it is clearly an unproven assumption that the effects of weather modification activities might get out of control. To date weather management has been conducted only on a localized basis. Macroscale operations would depend upon different processes than cloud seeding, and these operations may never get beyond the discussion stage.[119] Ignoring the possibility of

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114. *See* Bates, *The Role of Weather in Human Behavior*, in HUMAN DIMENSIONS OF WEATHER MODIFICATION 393, 401 (W. Sewell ed. 1966).

115. *Id.* at 403.

116. Haas, *The Many Views of Planned Weather Modification*, paper prepared for THIRD NAT'L CONF. ON WEATHER MODIFICATION (1972); Haas, Boggs and Bonner, *Science, Technology and the Public: The Case of Planned Weather Modification*, in SOCIAL BEHAVIOR, NATURAL RESOURCES AND THE ENVIRONMENT 151 (W. Burch ed. 1972); Haas, *Response to Planned Weather Modification: Implications for Urban Resource Management*, 1970 W. RESOURCES CONF. 251; Haas, *Sociological Aspects of Human Domensions of the Atmosphere*, in HUMAN DIMENSIONS OF THE ATMOSPHERE 53 (W. Sewell ed. 1968); Haas, *Social and Political Aspects of Planned Weather Modification*, in PROCEEDINGS OF FIRST NAT'L CONF. ON WEATHER MODIFICATION 202 (1968); Krueger, *Measurement of Attitudes Toward Weather Modification*, 2 J. WEATHER MOD. (WMA) 207 (1970); Saarinen, *Attitudes Towards Weather Modification: A Study of Great Plains Farmers*, in HUMAN DIMENSIONS OF WEATHER MODIFICATION 323 (W. Sewell ed. 1966).

117. Ackerman, *Economic Analysis of Weather: An Ideal Weather Pattern Model*, in HUMAN DIMENSIONS OF WEATHER MODIFICATION 61 (W. Sewell ed. 1966); Crutchfield, *Economic Evaluation of Weather Modification*, in WEATHER MODIFICATIONS SCIENCE AND PUBLIC POLICY 105 (R. Fleagle ed. 1969); Crutchfield & Sewell, *Economic Research Aspects of Human Adjustment to Weather and Climate*, in HUMAN DIMENSIONS OF THE ATMOSPHERE 59 (W. Sewell ed. 1968); Gutmanis & Goldner, *Evaluation of Benefit-Cost Analysis as Applied to Weather and Climate Modification*, in HUMAN DIMENSIONS OF WEATHER MODIFICATION 111 (W. Sewell ed. 1966).

118. *See* the statements of Representative Gude and Professor Matthew Meselson quoted in Shapley, *supra* note 113, at 1219-20; *Hearings, supra* note 4, at 57-58.

119. Triggering changes in the global air circulation patterns, melting polar ice caps and diverting ocean currents are some of the large-scale climate control operations that have been discussed. L. HARTMAN, WEATHER MODIFICATION AND CONTROL 29-31, S. REP. 1139, 89th Cong., 2d Sess. (1966).

It is also possible that the earth may suffer from large-scale climate and weather changes as the result of air pollution. This has been a matter of great concern not only to meteorologists. *See* S. BRUBAKER, TO LIVE ON EARTH 87-96 (1972) (Mentor paperback ed.); *Presidential Council on Environmental Quality, Man's Inadvertent Modification of Weather and Climate*, 51 BULL. AM. METEOR. SOC'Y 1043 (1970). *See also* Changnon, Jr., *Lessons from the La Porte Anomaly*, in PROCEEDINGS OF INT'L CONF. ON WEATHER MODIFICATION, CANBERRA, AUSTRALIA 193 (1971); Hobbs, Radke, & Shumway, *Cloud Condensation Nuclei from Industrial Sources and Their Influence on Clouds and Precipitation*, in *id.* at 237; Huff & Changnon, Jr., *Inadvertent Precipitation Modification by Major Urban Areas*, in PROCEEDINGS OF

human error, targeting is much more precise in these times of sophisticated ordnance deployed from aircraft than it was in the 1950's when many cloud seeders dispensed silver iodide particles by burning a solution of acetone and silver iodide in ground-based generators and depended upon air currents to carry the particles aloft.[120] Without careful observation and analysis of meteorological conditions it is possible to misjudge air movements and miss the target area. Both targeting and timing now can be controlled, however.

It has occasionally been asserted that weather management activities have had an adverse impact upon precipitation and runoff conditions. In *Adams v. California,*[121] a lawsuit in which a snowfall enhancement operation was alleged to have contributed to the 1955 Yuba City, California flood, the claimants were unable to prove that silver iodide seeding had contributed to the natural disaster.[122] In the first litigation involving artificial rainmaking, *Slutsky v. City of New York,*[123] resort owners who expressed fears that added precipitation

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THIRD NAT'L CONF. ON WEATHER MODIFICATION 73 (1972); Huff & Changnon, Jr., *Urban Effects on Daily Rainfall Distribution,* in PROCEEDINGS OF SECOND NAT'L CONF. ON WEATHER MODIFICATION 215 (1970); Langer, *A Study of Automobile Exhaust As A Source of Ice Nuclei,* in PROCEEDINGS OF SECOND NAT'L CONF. ON WEATHER MODIFICATION 242 (1970); Langer, *Ice Nuclei Generated by Steel Mill Activity,* in PROCEEDINGS OF FIRST NAT'L CONF. ON WEATHER MODIFICATION 220 (1968); Mohen & Vonnegut, *Weather Modification and Air Pollution,* in *id.* at 228; Schaefer, *New Field Evidence of Inadvertent Modification of the Atmosphere,* in *id.* at 163.

120. A pointed comment to the ineffectiveness of earlier ground-based seeding was made at the Bureau of Reclamation's conference on Optimization of Operational Weather Modification. According to Dr. Pierre St.-Amand of the Naval Weapons Center at China Lake, California:

> I want to repeat again that most people who seed clouds only think they are seeding clouds. In actuality, they are doing nothing at all. . . . The products from an acetone generator are not always what people think they are. If you are going to use these generators to seed clouds, be aware of what is coming out and what is reaching the effective level, evaluate the experiment in terms of what you are using. Good results have been obtained with acetone generators where the mountain is high enough so that you are above the freezing level.

OFFICE OF ATMOSPHERIC WATER RESOURCES, U.S. DEP'T OF THE INTERIOR, PROJECT SKYWATER PROCEEDINGS: SKYWATER CONFERENCE IV 105 (1968).

121. No. 10112 (Super. Ct. Sutter County, Cal., April 6, 1964).

122. The case is discussed in Mann, *The Yuba City Flood: A Case Study of Weather Modification Litigation,* 49 BULL. AM. METEOR. SOC'Y 690 (1968).

123. 197 Misc. 730, 97 N.Y.S.2d 238 (Sup. Ct. 1950). *See also* Samples v. Irving P. Krick, Inc., Civil Nos. 6212, 6223, and 6224 (W.D. Okla. 1954); Pennsylvania Natural Weather Ass'n v. Blue Ridge Weather Modification Ass'n, 44 Pa. D. & C.2d 749 (1968); Southwest Weather Res., Inc. v. Rounsaville, 320 S.W.2d 211, and Southwest Weather Res., Inc. v. Duncan, 319 S.W.2d 940 (Tex. Civ. App. 1958), both *aff'd sub nom.,* Southwest Weather Res., Inc. v. Jones, 160 Tex. 104, 327 S.W.2d 417 (1959); Auvil Orchard Co. v. Weather Modification, Inc., No. 19268 (Super. Ct. Chelan County, Wash., 1956). *See generally* Summerville v. North Platte Valley Weather Control Dist., 171 Neb. 695, 107 N.W.2d 425 (1961) (proceeding for allowance of attorney's fees and expenses from weather modification lawsuit); Summerville v. North Platte Valley Weather Control Dist., 170 Neb. 46, 101 N.W.2d 748 (1960) (attack upon validity of creation of weather modification control district); Avery v. O'Dwyer, 305 N.Y. 658, 112 N.E.2d 428 (1953) (propriety of denial of motion to amend title of summons and complaint in a weather modification case); Shawcroft v.

would wash out roads and bridges and otherwise disrupt their business did not prove their case. Just after the June 9, 1972, flood at Rapid City, South Dakota, questions were raised concerning the effect of experimental salt seeding that had been carried out in the Black Hills area earlier that day. An official investigative team concluded that it could not be established that the seeding contributed to the losses occasioned by the flood.[124]

It has been asserted that military precipitation stimulation has brought about flooding in Southeast Asia. While flooding is, after all, one way of hampering movements of troops and supplies, it has also been reported to have effected noncombatants. Jack Anderson put it this way:

> The only trouble with rain, as Jesus Christ pointed out, is that it falls on the just and the unjust alike. The same cloudbursts that have flooded the Ho Chi Minh trails reportedly have also washed out some Laotian villages. This is the reason, presumably, that the Air Force has kept its weathermaking triumphs in Indochina so secret.[125]

According to the doctrine of proportionality, the impact of the weapon must be proportionate to legitimate military objectives.[126] Given the ability of weather modifiers to target their activities, it would seem that not all rainmaking would result in materiel and human losses disproportionate to the objective of hampering military transport. Weather warfare, regrettably, may cause injuries to neutral parties and noncombatants and it may destroy property not dedicated to the belligerency. But most forms of weaponry have a similar potential of reaching beyond enemy military forces and equipment. While under some circumstances the use of weather modification as a weapon might be disproportionate to its military utility, that alone does not render it an improper weapon in other cases.

One of the misconceptions about weather modification difficult to lay to rest is the notion that cloud seeding to increase precipitation in one area will decrease precipitation downwind.[127] The "robbing

Dep't Natural Res., Civil Action (D. Ct. Alamosa County, Colo., Sept. 20, 1972) (challenge to issuance of license by state agency regulating weather modification); Reeve v. O'Dwyer, 199 Misc. 123, 98 N.Y.S.2d 452 (Sup. Ct. 1950) (ruling upon motion for change of venue of weather modification litigation); Pennsylvania *ex rel.* Township of Ayr v. Fulk, No. 53 (C.P. Fulton County, Pa., Feb. 28, 1968) (criminal violation of township ordinance prohibiting cloud seeding).

124. P. ST.-AMAND, R. DAVIS & R. ELLIOTT, REPORT ON RAPID CITY FLOOD OF JUNE 9, 1972 (Report to South Dakota Weather Control Comm'n) (1972).

125. Washington Post, March 18, 1971, § F, at 7, col. 6.

126. See text accompanying notes 102-04 *supra.*

127. The two main cases in which this allegation has been made split on their findings of fact. In Pennsylvania Natural Weather Ass'n v. Blue Ridge Weather Modification Ass'n, 44 Pa. D. & C.2d 749 (1968), the Court of Common Pleas of Fulton County, Pennsylvania, found that the plaintiffs had not proved that a hail suppression

Peter to pay Paul" argument is based on the curbstone logic which assumes that atmospheric moisture is similar to a stream on the land and that if you take a bucketfull upstream it is unavailable downstream. The analogy is inaccurate, however. Cloud systems are not like rivers. The dynamics of a cloud is just one factor other than the liquid water content that is crucial to precipitation. Cloud seeding has an impact on both the amount of moisture remaining in the atmosphere and the dynamics of the atmosphere.[128] The downwind effect is thereby not necessarily going to be a decrease in precipitation. It could be possible for an extra-target area increase in precipitation. Studies of the impact of seeding upon non-target areas have been infrequent.[129] If there are serious impacts outside the zone of intended military effect, then these physical aspects should also be considered in assessing the legitimacy of weather warfare.[130]

Scientific Considerations

During the Renaissance an illustrious citizen of Florence sought employment elsewhere. He wrote a letter to Lodovico Sforza, the Duke of Milan, whose realm was hard pressed by French expansionism. In the letter, the Florentine wrote nine numbered paragraphs in which he highly recommended himself as a military engineer. He had plans for portable bridges, various types of ordnance and "other engines of wonderful efficacy not in general use." He knew how to cut off water from trenches around cities under seige and could tunnel, "without any noise," even under trenches or rivers. In the tenth paragraph the job applicant also indicated, almost as an afterthought, that he could sculpture and paint. In this field he claimed that his "work will stand comparison with that of anyone else whoever he may be." It has indeed. The prospective employee was Leonardo DaVinci.[131]

Leonardo was not the first man of science whose genius was

project had contributed to drought conditions. In the *Southwest Weather Research* litigation the trial judge accepted testimony that hail suppression efforts had caused clouds to shrivel and shrink. The finding was upheld on appeal. Southwest Weather Res., Inc. v. Rounsaville, 320 S.W.2d 211, and Southwest Weather Res., Inc. v. Duncan, 319 S.W.2d 940 (Tex. Civ. App. 1958), both *aff'd sub nom.* Southwest Weather Res., Inc. v. Jones, 160 Tex. 104, 327 S.W.2d 417 (1959).

128. Kahan, *Weather Modification Effect on Man's Environment*, 1967 W. RESOURCES PAPERS, 1967, MAN AND THE QUALITY OF HIS ENVIRONMENT 81, 86-88 (J. Flack & M. Shipley ed. 1968).

129. *See* Elliott, Brown & Grant, Transactions of Seminar on Extended Area Effects of Cloud Seeding, Santa Barbara, Calif., Feb. 15-17, 1971.

130. During the early days of scientific weather modification some experimentors were convinced that Project Cirrus, which was conducted in New Mexico, produced results as far away as the east coast of the United States. These "results," though, were not generally accepted by the scientific community. *See* D. HALACY, THE WEATHER CHANGERS 88-92 (1968).

131. W. DURANT, THE RENAISSANCE: A HISTORY OF CIVILIZATION IN ITALY FROM 1304-1576 A.D. at 202-03 (1953).

turned to military engineering and weaponry. Probably the most famous incident in ancient history involving a scientist-warrior took place during the seige of Syracuse by the Romans in 212 B.C. In Plutarch's "Life of Marcellus," the historian tells of the role of Archimedes and the military equipment he invented.

> [H]e at once shot against the land forces all sorts of missile weapons, and immense masses of stone that came down with incredible noise and violence; against which no man could stand; for they knocked down those upon whom they fell, in heaps, breaking all their ranks and files. In the meantime huge poles thrust out from the walls over the ships, sunk some by the great weights which they let down from on high upon them; others they lifted up into the air by an iron hand or beak like a crane's beak, and, when they had drawn them up by the prows and set them on end upon the poop, they plunged them to the bottom of the sea . . . .[132]

Archimedes also devised catapults of adjustable range which would shower anti-personnel missiles at the Romans. In the end the Romans prevailed, however, and Archimedes was killed by an infantry soldier.[133] Bertrand Russell has commented upon this irony: "[o]ne can imagine the exultation of Roman Blimps at the proof that once more these newfangled devices of long-haired scientists had been defeated by the old tried traditional forces by means of which the Empire's greatness had been built up."[134]

It is arguable that scientists who, unlike Leonardo and Archimedes, pursue non-military research and development might well discover principles, techniques or devices which have potential military applicability. All scientific research conducted today has at least some possible military application.[135] Like it or not, and many meteorologists seem not to like it,[136] research into the peaceful uses of weather modification was seen almost from the outset as having a potential military payoff. General Electric sponsored the original work that led to cloud seeding.[137] The United States Navy took over where General Electric left off.[138] The Department of Defense has since been involved, along with several civilian agencies of the federal government.[139]

132. 1 PLUTARCH, LIVES OF ILLUSTRIOUS MEN 482 (J. Dryden transl., J. & W. Langhorne eds. 188—).
133. *Id.* at 485-86.
134. B. RUSSELL, THE IMPACT OF SCIENCE ON SOCIETY 72 (AMS Press ed. 1968).
135. This is well illustrated by UNLESS PEACE COMES (N. Calder ed. 1968); G. GRAY, SCIENCE AT WAR (1943).
136. *See* reports on the hearings by Senator Pell's subcommittee. *Hearings, supra* note 4, at 80-101.
137. *"Project Cirrus"—The Story of Cloud Seeding,* Nov. 1952 G-E REV. 8, 22-23.
138. D. HALACY, *supra* note 130, at 117-24.
139. Current reported involvement by federal agencies in weather modification is

Knowledge gained by the armed forces has been used by other governmental agencies and by commercial cloud seeders; and the military has utilized research conducted by the private sector as well as by non-military agencies.

The effect of military use of weather modification as a weapon does not appear to have induced any civilian scientists to discontinue research in the field. In its December 1971 assessment of priorities for the future of the atmospheric sciences, the Committee on Atmospheric Sciences of the National Academy of Sciences recommended that the United States "present for adoption by the United Nations General Assembly a resolution dedicating all weather-modification efforts to peaceful purposes . . . ."[140] At the hearings on the Pell treaty proposal, the president of the American Meteorological Society also urged that our government present a resolution to the General Assembly pledging all nations to refrain from devoting weather management to hostile purposes.[141] Nevertheless, civilian and military weather modification research, development and operations have proceeded hand-in-hand.

Government opponents of banning weather weaponry have expressed the fear that cutting off their work will adversely affect beneficial weather modification progress. The military has conducted drought relief programs both in the United States[142] and abroad.[143] It also has an interest akin to that of non-military entities in reducing hazardous weather conditions. It is not necessary to be a General Howe to wish to suppress fog or desire to reduce the force of hurricane winds. The Navy's interest in fog dissipation for the Panama Canal[144] and in Project Stormfury, the national hurricane suppression project,[145] is as legitimate as that of its partner, the National Oceanic and Atmospheric Administration. The military fears that these undertakings would suffer from any ban on weather modification as a weapon. The

stated in INTERDEPARTMENTAL COMMITTEE FOR ATMOSPHERIC SCIENCES, NATIONAL ATMOSPHERIC SCIENCES PROGRAM: FISCAL YEAR 1972 (ICAS Rep. No. 15) (1971).

140. National Academy of Sciences, THE ATMOSPHERIC SCIENCES AND MAN'S NEEDS: PRIORITIES FOR THE FUTURE 61 (1971).

141. *Hearings, supra* note 4, at 88. The World Peace Through Law Center, a private organization, has prepared a draft protocol on weather modification. Samuels, *Draft Protocol on Weather Modification*, World Peace Through Law Center, Pamphlet Series, No. 15.

142. Sax, Cress & Matthews, *Convective Cloud Modification in Texas*, in PROCEEDINGS OF THIRD NAT'L CONF. ON WEATHER MODIFICATION 214 (1972).

143. St.-Amand, Reed, Wright & Elliott, GROMET II: RAINFALL AUGMENTATION IN THE PHILLIPINE ISLANDS (1972).

144. The National Oceanic and Atmospheric Administration, as well as the Navy, has an interest in the program. *News & Notes*, 52 BULL. AM. METEOR SOC'Y 1188, 1251 (1971).

145. DEP'T OF THE NAVY & ESSA, PROJECT STORMFURY, ANNUAL REPORTS (1965-68) (classified). *See also* Howard, Matheson & North, *The Decision to Seed Hurricanes*, 176 SCI. 1191 (1972).

Nelson rider, which spoke of the "military application of weather modification techniques,"[146] appears on its face to reach these non-hostile uses of weather management as well as banning use of appropriated monies to bring down rainfall on military roads and hamper communications by the enemy. Beneficial and peaceful uses would thereby be hindered.

Not only do American meteorologists cooperate among themselves, but there is also extensive international cooperation among weather scientists. Forecasting is materially improved by the wide interchange of weather information. World Weather Watch, a program designed to upgrade instrumentation for obtaining information and to improve the international exchange of information, has been successful.[147] One of the fears expressed about military use of weather modification is that it will impair these efforts.[148] Nations at war with each other do not share weather information. Use of weather modification for military purposes will not change that. Whether United States use of weather warfare will induce non-belligerents not to cooperate with the United States is a separate question. The flow of weather information to this country has not been cut off. At least one article suggests, however, that potential Russian-American exchanges of weather modification information may have died because of the revelations that we have been using rainmaking as a weapon.[149]

International Relationships

If there is no international regulation of weather modification used for military weaponry, nations other than the United States will

146. 118 CONG. REC. 12,186 (daily ed. July 28, 1972). Although the language does not contain an exception for peaceful application of cloud seeding by the military, Senator Nelson in his comments on the Senate floor asserted that his rider was "not intended to cut off funds for research or for operations which have peaceful purposes. Cloud-seeding causing flooding for the enemy would be prohibited. But, for example, fog dissipation operations over U.S. airstrips would not be prohibited." *Id.* at 12,187. One wonders if the Senator would be in favor of fog dissipation at airfields from which bombing attacks upon North Vietnam were launched.

147. Meteorologists have enjoyed good international working relationships. Even during the period when the Peoples' Republic of China was in "isolation," they broadcast weather information and the information was used by other nations in preparing forecasts.

148. Thomas Malone, one of the organizers of the Global Atmospheric Research Program, has been quoted as saying, "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." And Joseph Smagorinsky, another GARP organizer, has asserted "[t]hese programs are a cooperative effort of many nations, and each gives up a certain amount of autonomy to work together. . . . If they felt this would be used against them, there would very definitely be a cooling off." Shapley, *supra* note 113, at 1218.

149. Shapley, *Science Officials Bow to Military on Weather Modification*, 177 SCI. 411 (1972).

be tempted to engage in weather warfare research and application. The basic principles of cloud physics and dynamics are internationally known and enough has been written in scientific journals to make it possible for most nations to undertake a weather weaponry program. The Soviet Union has long had an interest in weather management. They have pioneered in the use of artillery and rockets as delivery systems for seeding, and they have embarked upon a hail suppression program.[150] Should the Russians choose to devote their energies to study the military uses of weather modification, and then actually employ cloud seeding as a weapon, we would be hard-pressed to claim any impropriety. Another weapons system will have been added to the arms race at the same time we have been attempting to de-escalate that race in the Strategic Arms Limitation Talks.

Under certain circumstances, international law sanctions the use of otherwise prohibited weapons for retaliation and reprisal.[151] The Germans, who began the massive use of chlorine gas at Ypres on April 22, 1915, insisted that prior French use of tear gas violated the Hague pact and permitted them to retaliate.[152] Thereafter both the Central Powers and the Allies entered into wholesale gas warfare. The Germans, who were downwind most of the time and who did not have the technical resources of the Allies, were to regret rejecting the advice of Professor Fritz Haber who had developed their chlorine gas. He had recommended that the high command be prepared to exploit its use to the fullest. The Germans were not prepared to follow up their advantage at Ypres, however, and within a short time the British and French had improvised gas masks. By the end of the war the Germans had suffered 200,000 casualties from gas warfare.[153]

Unless we refrain from future use of weather modification in armed conflicts, the United States will be open to the use of weather warfare. Given the present state of the art and our national defense system, we would be relatively free from effective retaliation in most parts of the country. Cloud seeders must get rather close to their target cloud systems in order to determine the right place to insert the silver iodide. Long range missiles cannot do this; penetration by manned aircraft would be necessary. The possibility for such penetration may exist along coastlines and in border areas, but cloud seeding flights further inland could be intercepted before any seeding was done. Should

150. *See* L. BATTAN, HARVESTING THE CLOUDS: ADVANCES IN WEATHER MODIFICATION 95-97 (1969).
151. Stowell, *Military Reprisals and the Sanctions of the Law of War*, 36 AM. J. INT'L L. 643 (1942).
152. W. GRAY, *supra* note 135, at 160-61.
153. *Id.* at 166.

we ever be in the position of the North Vietnamese and Viet Cong where an enemy has control of the air, however, we then would be vulnerable to the possibility of weather warfare being turned upon us.

If a way is found to take weather modification from the list of acceptable weapons, a question might be raised about the enforceability of such a ban. A nation which uses aircraft in hostile operations would probably be able to mix cloud seeding with the more conventional uses of military aircraft. Seeding materials can be carried on anything from single engine spotter planes to giant bombers. It has required the most delicate neutron activation analysis to determine whether any silver is in a rainfall sample.[154] Natural weather cycles cause such large variations in precipitation that a country subjected to hostile cloud seeding might not be aware of having been the target of hostile weather modification. Thus a clandestine operation might not be detected. There appears to be no equivalent to the "spy in the sky" satellite that helps enforce the nuclear test ban treaty.

CONCLUSION

An old maxim says that "all is fair in love and war." If that is true of love, it certainly is not true of war. Should weather modification join dum dum bullets and asphixiating gases on the proscribed list? It is submitted that a general ban on military involvement with weather modification would be inappropriate. It is necessary to distinguish among the different types of weather modification and among the situations in which they may be employed. Any norms derived should be developed with the idea of imposing minimal limitations on research and development for peaceful purposes. Lives and property may be saved by allowing the military to continue its work with non-hostile weather modification. If the Air Force and Navy are shunted from their roles in development of fog suppression and severe storm management, other agencies working with them with limited capacity to deliver the seeding agent to the target will be severely crippled. Rainmaking over friendly territory to screen military operations would seem to be not unlike the accepted practice of laying down smoke screens. Fog clearance for improvement of transportation efficiency is not greatly different from using other means to penetrate murky weather.

154. *See* DOUGLAS, THE SILVER IODIDE GENERATOR AND PUBLIC HEALTH (1968). For analysis of an Australian experiment, see Warburton & Maher, *The Detection of Silver in Rainwater: Analysis of Precipitation Collected from Cloud-Seeding Experiments*, 4 J. APPLIED METEOR. 560 (1965).

The real issues of military use of weather modification are whether hostile cloud seeding over enemy-controlled territory in order to cause harm is barred by law and, if not, whether as a matter of sound policy such use of weather modification should be banned. On the basis of present law such conduct would not seem to be unlawful. In balance, however, policy considerations indicate that weather management should be withdrawn from the military arsenal. This, though, should only be accomplished by measures that are more selective in their sweep, better drafted and more thoroughly considered than the Nelson rider, the Pell treaty proposal and the Stockholm Declaration.