

CLOUD SEEDING

THE TECHNOLOGY OF FRAUD
AND DECEIT

(A criminally conspired complex)

by

THE TRI-STATE
NATURAL WEATHER ASSOCIATION, INC.

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The purpose of this publication is to expose the fraud, deceit and dangers of uncontrolled and unregulated cloud seeding; to reveal to the public that cloud seeding is not rain making, and that 90% of all cloud seeding is employed expressly for the purpose of decreasing rainfall. Also, that cloud seeding is the weapon responsible for our serious air pollution problems.

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Tragedy in the Potomac Basin

South Central Pennsylvania and adjoining states of Maryland, West Virginia, and Virginia encompasses an area that is drained by the Potomac Basin. A glance at a map will show that the Potomac basin includes parts of several physiographic regions — the Piedmont, the Blue Ridge, the Ridge and Valley, and the eastern slopes of the Allegheny front. Climatically this basin is a sort of a transitional area between the north, with its long, severe winters; and the south, with its short, mild winters — latitudinally it is situated at about 40 degrees north. The Potomac basin is compact in area so that the climate is homogenous throughout except for small temperature differences between the higher and lower elevations.

Standard texts in geography describing the climate read as follows: "Few other agricultural areas in the Eastern United States receive so much annual precipitation — few stations in the Potomac Valley get less than forty inches of annual rainfall. Maximum rainfall, in the form of thunderstorms, comes in summer when crops need it most. Hardly a week passes without a good rain, though this region, like most others, does have its occasional dry spell that may last for a period of two or three weeks. The short drought is suddenly broken by torrential downpours. Generally the precipitation pattern is considered reliable, because the amounts received are usually consistent from year to year, season to season and month to month."

Adequate and reliable precipitation has been the key to the long history of successful agriculture in the Potomac basin. A reliable precipitation pattern means that the amount received will not vary significantly from the normal amounts for the month or for the year. For example, the total annual precipitation at Gettysburg, Pennsylvania, is around 40 inches per year. An examination of the precipitation records prior to 1957 will show that the year to year precipitation deviates around this average; one year it will be one to three inches above the average and the following year it will be one to three inches below. Small random fluctuations are also evident in the monthly precipitation records at the Gettysburg station. In contrast, an unreliable precipitation pattern is one where the monthly or annual amounts received fluctuates erratically and extremely above or below the normal which may endure for several or more periods. An example of the unreliable type of precipitation pattern is what is found in the marginal dry areas of western Kansas and Nebraska where agriculture is limited to hardy grains and grazing.

The successful diversified agriculture of the Potomac region has been the result, first because of the plentiful and reliable precipitation; and, secondly, because of the good quality soil combined with moderate temperatures. The combination of these elements in the past made the agriculture community of the Potomac drainage system one of the most flourishing in the United States.

After 1957 the previous description of the climate in this area has undergone a dramatic change with the result that the once prosperous agriculture community has suffered losses that will never be recovered, not to mention water shortages by towns and communities and the dried and burnt lawns of residences. Total annual precipitation no longer fluctuates in a random pattern around the average. For most years since 1957 it has been almost consistently below the average. The deficiency in rainfall is mostly during the summer growing months of July, August, and September. No longer does one see the towering and majestic thunderheads that

indicated the approach of heavy downpours. In fact, it is one month after another of severe drought during the growing season producing a likeness of the southwestern United States rather than the lush green that was so typical of the Potomac Valley.

Former residents returning for visits or others who are visiting for the first time inquire about the dismal conditions and reflect in expression their dismay and disappointment.

The answer to the dilemma is cloud seeding or weather modification. The history of cloud seeding in the Potomac Valley goes back to 1957 when some of the fruit growers, for the first time, employed a weather modification service for the purpose to seed thunderstorms to diminish the possibility of hail damage. The result was a decrease in hail, and, unfortunately, the rainfall was also drastically reduced because the thundershower activity was completely disarranged and destroyed. Each year after 1957 the increased efficiency of the cloud seeding activities became more evident. The increase in the efficiency of thunderstorm destruction was probably because the practitioner was gaining more knowledge of the climatic variables in the area and the technological methods were being improved. The cloud seeding activities in the Potomac Valley during the early 1960's is documented in the record of hearings before the Committee on Commerce, U. S. Senate, 89th Congress, Bills S. 23 and S. 2916, 1966; and in a Report prepared for Senator Magnuson, U. S. Senate, April, 1966. Public indignation and objection to the cloud seeding activities after 1966 caused the promoters and practitioners to pursue a more clandestine and cautious course in carrying out their activities so as not to further enrage the embittered public. Obviously the earlier successes gave encouragement to others who saw the possibilities to promote selfish interests and schemes by the use of cloud seeding to diminish precipitation in the Potomac Valley.

It is a popular belief of many of our citizens that cloud seeding is synonymous with rain-making. Unfortunately, this popular belief has been the result of the myriad of articles and stories published in the news media throughout the country. The basis of these stories has obviously been the deliberate efforts by the practitioners of cloud seeding to create a gracious and benevolent image for themselves. This can be expected because they are in a business that grosses hundreds of millions of dollars each year.

The real truth of cloud seeding is found in the scientific literature. A case illustration is "Operation Whitetop" which was a five-year scientific project combining the efforts and resources of a federal government agency and a large mid-western university to test the hypothesis "that cloud seeding would significantly increase precipitation." After five years of research the hypothesis was rejected and the conclusion was that cloud seeding actually diminished precipitation by as much as thirty percent in the immediate target area and that there were lesser amounts of precipitation than what would have normally fallen for at least 125 downwind.

A basic law of the atmosphere is "precipitation must equal evaporation and transpiration." No one can make rain! The amount of precipitation can be altered by shifting and guiding storm systems from one area to another or vice versa. Question the credibility of anyone who claims that he can produce rain by cloud seeding. Any fundamental text in meteorology or physical geography will definitely state that precipitation cannot exceed the evaporation plus transpiration.

What is cloud seeding or weather modification? The discussion here will be limited to the chemical process which uses silver iodide as the

nucleating agent. Of the many chemical agents used in cloud seeding, silver iodide is used by more than 95 percent of all commercial practitioners because of the simplicity in its technical applicability and because of its efficiency in altering the local weather conditions. Anyone who has access to a twin-motored plane can set himself up in the cloud seeding business with an investment of as little as three thousand dollars. Small metal racks to hold the pyrotechnic flares impregnated with silver iodide and the flares are the essential equipment to set-up a practitioner in business. It is known that some practitioners do not even bother to install the visible incriminating evidence of metal racks on their planes, but instead use especially made flares that are thrown from the plane's window.

To describe what silver iodide does in cloud seeding will, first, necessitate a brief description of the natural precipitation process. It can be generally stated that precipitation depends on falling temperatures, a sufficient moisture content of the air, and the presence of microscopic nuclei. These microscopic nuclei may be dust or ice particles, and their presence is essential in the rain-making process. A typical summer thunderstorm generates its own nuclei in the form of ice crystals near the top of the cumulo-nimbus cloud. The moisture in the cloud has an affinity for these ice crystals and, therefore, condenses on them. The process of condensation continues until each drop of rain sufficiently increases in size and then falls to the earth's surface by gravity. Cloud seeding is the introduction of additional artificial nuclei, silver iodide crystals, into the thunderstorm system. The silver iodide crystals and ice crystals have similar characteristics and, as a result, the moisture in the cloud will also condense on a silver iodide crystal as it does on an ice crystal. The silver iodide is introduced in the air usually by aircraft which flies sufficiently close to a thunderstorm but not into it. The silver iodide from the burning flares is pulled into the storm system by the convective air currents. The introduction of the silver iodide nuclei with the natural nuclei already present in the thunderstorm has the effect of stopping the cycle of the rain-making process. When too many nuclei are present, natural and artificial, the limited amount of moisture in the cloud is not sufficient in quantity to condense on all the nuclei to form sufficiently large rain drops that will fall to the earth. The rain-making process is stopped. The condensing moisture is re-evaporated and carried downwind where it will be taken into another storm system and fall in such quantities which sometimes produces disastrous floods.

The incidence of many floods in the United States is obviously connected with cloud seeding in adjacent areas. It may be difficult to prove, but the fact remains that cloud seeding was being done. Promoters and practitioners of cloud seeding always say "prove it!" On the other hand, they have yet to prove that cloud seeding does not cause floods. In fact in the Senate Hearings, 89th Congress, Bills S. 23 and S. 2916, 1966, a prominent practitioner of cloud seeding boasted that he carried very little liability insurance for possible damages because it would be very difficult for a plaintiff to prove in a court of law that cloud seeding had caused damage. Thus it is certainly a travesty of justice that a cloud seeder has such protection and this demonstrates why they can act with such arrogance and brazenness.

Throughout the years since 1957 there have been continuous summer droughts in the Potomac Basin, but, on the other hand, there have been torrential downpours and flooding only 75 or 100 miles downwind in Eastern Pennsylvania, Maryland and New Jersey. Another example of floods is the Rapid City disaster in 1972. It is a documented fact that a cloud seeding

run had been made less than one hour before the torrential downpour in the Black Hills.

More and more law suits are being brought before the courts seeking flood damages in areas downwind from cloud seeding activities. Just as recently as January 1975, the *FARM JOURNAL* on page 42 lists court action seeking flood damages in Michigan and Oklahoma, that were the result of cloud seeding in adjacent areas. In both states the suits are against Irving P. Krick of Palm Springs, California, who is a practitioner of cloud seeding and whose lucrative operations extend beyond the boundaries of the United States.

An Ecological Massacre

Cloud seeding is a science, a science of doom, devastation and desecration. The spectre of cloud seeding indicates destructive floods, unprecedented droughts and the key to all our air pollution problems in the United States. This ecological problem has evolved by mad pseudo-scientists dumping lethal doses of poisonous materials into the atmosphere to change it for their own greedy desires.

Never in our history has a scientific blunder been conducted with total fraud and deceit. The generalized procedure of the cloud seeder is to make exaggerated claims of rain making when drought is the desire. Federal bureaucratic enuchs conduct experiments creating severe drought but tell legislators they increased rainfall and need more money to create more man-made drought. Probably the greatest boondoggle was the especially created five-year drought in the Northeast, the result of irresponsible cloud seeding. Cloud seeding is being carried out extensively and intensively over the entire nation. The build-up of pollutants used during the past decade are frightening. Whenever clouds are seeded layered air inversions occur holding man's air pollution next to the earth's surface and creating our "sewer in the sky." Man is not emotionally stable under this biological situation created by heavy cloud seeding. He will riot, murder, rape, steal, commit suicide, and in general cannot live compatibly with each other. Natural weather is the only way mankind can live happily and in biological compatibility with his environment.

Natural Weather Important

First it should be explained in more detail why our weather is so important in its natural state. To begin with, it brings us the rains so essential for food production and industrial growth. It is only by the natural weather patterns that fresh air is available to sustain life. Man's pollutants are washed out of the atmosphere by rainfall. Thunder storms, with their up-drafts and concurring down-drafts, mix the air and dilute the poisonous wastes. Lightning, a product of thunder storms, is the world's greatest producer of nitrogen. Without it there would be no life on this earth. Even the most destructive storms have a purpose. It is the release of excess energy, and if not occurring regularly would be utterly catastrophic. Tampering with these storm systems by cloud seeding can do nothing more than upset the delicate balance of nature. Storm systems are, in reality, nature's giant washing machines.

The mania of the cloud seeder is certainly evident since his desire is to eliminate the storm systems. If he is allowed to continue unabated with his unlawful methods, man will soon vanish from the earth's surface.

Rain-Making Is A Myth

Never has there been anything as rain-making. It can only be re-distributed or moved around. Of all the scientific efforts to increase rainfall, there is not one shred of evidence that cloud seeding ever produced one drop of additional rain.

We are also told by the scientists that there are rivers of water in the sky. Yet they admit that the air around the globe cannot hold more than one inch of moisture at any given time.

A summary of five cloud seeding experiments evaluated by Neyman & Scott, of the University of Berkeley, with results presented at the Fifth Berkeley Symposium, had this to say:

The evidence that cloud seeding *decreases* rain comes from five American experiments. These five randomized experiments were conducted with unchallenged reliability over a number of consecutive years with considerable care and foresight — the results are a decrease in precipitation due to seeding and the estimated decreases amount to 53%.

Project White Top centered in Missouri presented nothing but bad news. Increases of rainfall were hoped for but final results were most conclusive with decreases of 21-23%. There are of course exceptions in any type of scientific endeavor. When cloud seeding takes place during extremely wet periods, floods are bound to occur. Probably the reason for this is the shortage of natural nuclei in the air necessary for water droplet formation. Whatever the circumstance, "rain-making" just sounds good.

Twenty years ago Cloud Seeding started making great and exaggerated claims of increased precipitation. It was soon found out that the exact opposite occurred. It didn't take long for those with greedy intent to take advantage of this interesting discovery. The purpose of this publication is to expose to the people of this earth one of the greatest rackets ever known — far more sinister and damaging than any underworld activity.

One can only guess as to the amount of money spent annually for Cloud Seeding, but estimates place it at nearly \$3 billion, which includes both governmental and private projects. This insidious tampering apparently has served its purpose as this country is now at its driest in 8000 years.

Why "Drought" Is Never Mentioned

Almost to a man, the weather community has adopted the policy of emphasizing the positive approach, that of "making it rain," as it will be welcomed by the general public.

"Making rain" sounds good to congressional appropriation committees, too. Can one imagine a United States Senator voting for funds to make droughts? How would the farmers, gardeners and townspeople whose reservoirs get low in his state vote in the next election?

However, both scientists and federal scientific literature now speak casually and openly of lightning suppression, fog dispersal, hail suppression, snow suppression — all accomplished by drying up the cloud by over-seeding with dry ice or silver iodide.

Dr. Schaefer, a father of weather modification, told *This Week Magazine* in 1968, "We know that a certain amount of silver iodide introduced into a cloud can cause precipitation but we also know that a very LARGE amount

SUPPRESSES rain by creating so many particles that they are often too small to fall, or if precipitation does develop, it is not normal rain but those tiny particles that look more like fog or mist.”

Who Wants Dry Weather?

The reasons for seeding are as varied as man's desires but the liking for dry, clear weather seems more prevalent than the desire for rain. Clear weather is wanted for recreation, for airports, to prevent hail-damage to fruit during the maturing months of June, July and August, to maintain a dry earth bed for pouring concrete for footings, roads and parking lots; for constructing high-powered electric plants and for pouring concrete for large apartment and office buildings.

The Insurance Federation claims that weather modification will save them \$186,000,000 annually if the storms that bring the necessary rains are destroyed. The construction industry will save \$500,000,000 annually if it is not delayed by the weather. Utility companies don't want damage to their power lines.

Air Pollution from Cloud Seeding

Cloud seeding is responsible for 90% of all the air pollution problems in the United States. The statement of Dr. E. J. Workman helps point up this fact. Generalized seeding of immature cumulous clouds will result in a stabilization of the atmosphere that will prevent the development of mature clouds to produce rain. This sets the stage. Under this condition air pollution is now a problem, there is no turbulence in the atmosphere to dilute man's poisonous pollutants. No rain to wash the filth out of the air. Thermal inversions occur and do not cease until weather patterns regather their momentum.

Silver iodide used for nearly all cloud seeding under these conditions is now most dangerous to man.

For instance, what knowledge have the scientists on how cloud-seeding materials relate to other substances and is that taken into consideration before dumping it on the clouds and ultimately on the people.

Silver iodide breaks down quickly but the iodine atom appears to recombine with other substances such as resins from pine trees which yields a terpene vapor which produces an unintentional seeding material capable of continuing the drought in the area.

A tiny trace of iodine is needed to combine with the lead pouring from auto exhaust pipes to make deadly poison. These materials fall-out onto grass, eaten by cows, then into all dairy products, then to man. Iodine concentrates in the thyroid gland and can produce cancerous nodules years later.

The death rate in 1966 — the year of heaviest seeding in southern Pennsylvania counties — from lung diseases reached the highest number since vital statistics were kept, according to the Pennsylvania Department of Health, 1967. Cases of emphysema and lung cancer rose alarmingly in the last ten years.

Silver from silver iodide as it flows into the ecosystems will concentrate in the various organisms and thence to man, causing a buildup in the human

system to a toxic level. Silver iodide is a vicious corrosive and carcinogenic-causing substance; the inhalation or ingestion of this material will lead to respiratory or gastric ailments and cancer.

Silver iodide is used 90% of the time to do cloud seeding. It is extremely dangerous and poisonous. An accepted principle in the use of dangerous materials is that anything that can go wrong will eventually go wrong if the materials are used often enough. This is the cloud seeding problem from the poisoning aspect. Already mankind does not live as long as he did just several years ago — directly related to poor environmental quality caused by cloud seeding.

In operation, silver iodide is usually mixed with acetone and pyrogallol acid. These poisons as described in the U. S. Dispensatory, Merck Manual, etc., show the dangers. Silver causes argyria, skin lesions; pyrogallol attacks liver and kidneys; acetone, pulmonary congestion and death by ketoses. Iodine salts are also used as tracers. They have a toxicity of 5 or 6 and symptoms include anorexia, paresis, spasmodic respiration, asphyxial convulsions, wide-spread inflammation and fatal hemorrhages in lungs, liver, kidney and heart. The organ most severely affected is the liver and death may occur from hepatic necrosis.

Until cloud seeding is brought under control, air pollution shall remain one of our most serious problems.

Who Owns the Air

The air in the United States belongs to everyone, to be used in its natural state. Anyone, government or private individual, who does cloud seeding is in violation of statute law as well as every moral and ethical code ever devised. Cloud seeders know this, so they give false information, tell lies, exaggerate the truth and ask the various government agencies to cover up for them. P. H. Whyckoff, of the National Science Foundation, has been giving out false information for years. Yet with all of this conceived fraud, cloud seeding is still illegal.

Rain Making Fraud

Cloud seeders say: "We increased rainfall by 14%." This sounds good until the figures are analyzed. Cloud seeding takes place before the clouds begin to rain. In the process of dissipating, a few drops of rain fall. Since this precipitation drops after seeding, the cloud seeder tries to pawn his crime off as one of rain making. Had no seeding taken place, all of the available potential rain would have fallen. This represents 100% but only 14% fell. It can conclusively be stated that cloud seeding decreases rainfall by 86%.

Seeding Techniques

Under-seeding may make the cloud rain or snow but at the expense of farms and towns downwind.

Over-seeding does several curious things, depending partly on the materials and the technique used and the size of the cloud.

Over-seeding with silver iodide may cause the cloud to rain or snow slightly, then to break up and drift into mist within 10-30 minutes. Depending on the size of the cloud and the dosage, it will not rain for 10

miles or 50 or 150, but meanwhile the unexpended energy builds up and eventually the rain comes down as a cloudburst on a distant city, such as 7 inches in Philadelphia in 1968, 3 inches in 15 minutes in Washington, 9 inches in Los Angeles in 1969.

Dry ice and silver iodide will make the cloud freeze up, that is, "glaciate" and hang motionless in the sky for a number of hours. Sometimes the cloud will build up enormously but it will not rain.

Thunder Storms Are Essential

Nearly 4,000 thunderstorms have been lashing the earth 24 hours a day, year in and year out, through all of time since the world began.

Without these storms, there would be no life on earth. There would be no mixture of the air between layers. Pollution from dust, smoke and other foreign matter would increase to the point of causing death.

Lightning is the world's greatest producer of nitrogen compounds, the vital soil ingredient without which most plant life could not exist.

This is the only source of nitrogen for the forests which cannot grow without it. Notice that trees and plants in seeded areas look droopy, tired, and in many places entire kill is noted. Scarlet oak is one variety that died.

This nitrogen breaks down easily in soils and water and causes no problems.

Weather modification barbarians have plunged into spraying and shooting the clouds to control lightning without once studying the contributions that lightning makes to the earth.

Nowhere in all the pseudo-scientific literature is there a mention of the value of lightning strokes to man.

Hurricanes Are Also Important

Project Storm Fury conducted by E.S.S.A. and the U. S. Navy have kept hurricanes from coming up the eastern seaboard for nearly ten years. These massive storms are necessary for man's survival. They bring 30% of the moisture to this area — moisture that is so desperately necessary to grow food to feed a hungry world. Even more important, it is necessary for this type of system to disperse the high temperatures found near the equator. Hurricanes travel towards the north pole and this eventually tends to equalize high temperature variation. If hurricanes are not allowed to go their full life cycle, nature will find some other way to maintain heat balance, and this new method undoubtedly will be more disastrous than the hurricane. These systems also help tremendously in eliminating air pollution problems that are so serious on the east coast.

Hurricane Camille, the most destructive tropical storm to ever transverse the east coast, is without question due to the blunderings of the inept science. Inquiries indicate Camille was seeded over water and factual visible evidence of seeding was indeed observed as she passed over land. What happened in this situation is a cloud-seeding experiment getting out of hand. It represents a situation where reversible or cascading effects on atmospheric processes take place. The people who died from this hurricane were killed by scientific blunderings making those who tampered with this storm absolute murderers. The government of this country must take full blame for this terrible

calamity and are morally obligated to endow every human who suffered damage from this intensified storm. Hurricanes must be allowed to run their natural course as they are the good fairy for the Northeast and are one of the great water wheels in nature's water cycle.

Mysterious Program

A massive program of cloud seeding apparently entirely outside of the official federal programs on weather modification reported to Congress and funded from unknown federal sources, has been going on spasmodically since 1954 and steadily since 1962. This program has resulted in severe-to-extreme drought in virtually every area where conducted.

The Appalachian Mountains guaranteed the Atlantic Coastal Plains a healthy quota of rain each summer and no drought showed in the weather statistics with the single exception of 1930, which emphasized statistically the drought was man-made.

Then, senatorial and departmental sources stated the U. S. Army was cloud seeding behind military secrecy in Pennsylvania counties in 1962-1966 and in Tennessee in 1964-1966.

Since the seeding in Pennsylvania took place during the months of growth of June, July and August, the principal effect was aimed at the farmer to drive him off the land.

The areas of severe drought coincides exactly with the area the federal government plans to devote to population and light industry. With a few, limited exceptions, the farmer is to be eliminated. The same plan applies on the Pacific Coast.

Federal agencies with giant land-acquisition programs want the farmers and rural people put into a depressed economic state willing to accept any price for their lands for parks and reservoirs.

For verification, send for the Jury Trial Hearings, 1968, before the U. S. House of Representatives Public Works Committee, Washington, D. C. and read what happened in Tennessee.

The economic loss from drought caused by more than 10 years of cloud seeding on the Atlantic seaboard is unimaginable. The losses in one Pennsylvania county for the period 1957-66 for corn and silage and hay are estimated at more than \$30 million.

An Issue of Morality

Who shall receive the greatest priority? Destroying the weather for reasons of greed, or shall the people of this earth learn to live with the weather? For the farmer to raise food for everyone's needs, it is necessary for adequate and natural rainfall. Cloud seeding does not promote this type of natural weather. Even now food production on this earth is not keeping pace with the expanding population. No longer dare cloud seeding be allowed that will be harmful to agricultural production.

Integrity of the Cloud Seeder

There is no integrity by those in the cloud seeding community. Recent magazine articles, "Tell us the Truth, Uncle Sam," and "The Great Research

Boondoggle," in the National Science Foundation are indications. Never in the history of research have such absurd lies been perpetuated by governmental hacks and those doing private seeding. Two recent statements by P. H. Wyckoff of the National Science Foundation were "Silver iodide makes rain," and "Silver iodide never stopped rain." Both of these statements are false. Research has proven positively no overall increases in precipitation. And when it comes to stopping rain, silver iodide is the best material known. Hurricanes, thunder storms and the massive Great Lakes storms are all destroyed with silver iodide. Charles Hosler, of the Pennsylvania State University, continually tells the press that cloud seeding makes rain and is of benefit to the farmer. Yet this man runs experiments that do nothing but eliminate agriculture. He also gave false information about cloud seeding results to a recent Senate hearing. These ruthless governmental employees attempt to create a good image of their actions by promoting a self-serving policy of official deceit. Private practitioners of cloud seeding use the same shabby practice to debase the quality of democratic integrity. When W. E. Howell was asked at a senate hearing about damages he inflicted by drought, he merely replied: "The burden of proof lies with the plaintiff."

Cloud Seeders vs. Law

The cloud seeders, both Federal and private, refuse to obey the laws that have been set up in the past. Any one seeding was required to register with the National Science Foundation. Only a few "remembered to do so." A recent Senate Hearing said they had no idea how many people were in the business (racket).

Maryland barred cloud seeding entirely. Pennsylvania and West Virginia require a license. Yet cloud seeding goes on completely uncontrolled in these states. The National Science Foundation was required to enforce and stop illegal cloud seeding. They not only refused to enforce the legal action given them, but encouraged cloud seeders to ignore the law. This was accomplished by having the seeder register with the foundation, but then keeping all agreements confidential. If weather modification is such a glorious invention of our great society why must the evidence be buried. One would gather that it is an underworld activity, not a scientific endeavor.

Disrespect of law and order by governmental bureaucratic officials and lackeys is a national scandal in the field of weather tampering. Their chief excuses are to deny what they did or try to put the blame on man-made air pollution. Results are most conclusive, that man-made pollutants have a tendency to increase air turbulence and then a gradual increase in storm activity. These wicked pseudo-scientists refuse to abide by States Rights, by setting up and operating mammoth cloud seeding projects which the state laws strictly prohibit.

A scheme designed by E.S.S.A., called the Baltimore Project, was instigated after the State of Maryland completely banned all cloud seeding. Dereliction of duty is how the law has been enforced in Pennsylvania where a licensing procedure is in effect. Only those who are seeding for rain-making will be granted a license by this law. A weather board handles all requests and controls regulations. The Board is chaired by the Secretary of Agriculture. In cooperation with Federal pressure, the secretary abandoned his agricultural constituents, deactivated the weather board and had the State Police conduct

a gestapo investigation of the citizens who insisted on statute enforcement. And then cloud seeding continued more recklessly than ever. According to Washington reports, even the Pennsylvania State University refused to abide by this law.

Lawlessness and disorder shall continue to rule this country until our national government repents and sets an example of reformation.

Cloud Seeding in the Potomac River Basin

The Potomac River Basin or Mid-Potomac includes the states of Maryland, Virginia, West Virginia and South Central Pennsylvania. This area also encompasses a large fruit growing belt. A number of greedy fruit producers of this section engineered their orchards for irrigation. Then with prodding from the Insurance Company of North America, they organized a Weather Modification Corporation, and hired a cloud seeding firm to destroy the rain storms. The greedy desires of the fruit growers was to eliminate competition from the other growers who could not irrigate. The insurance company's greed was pocket padding by not having to pay storm damages that might occur. The greed of W. E. Howell, the cloud seeder, was to make a fast buck.

A state of war finally developed in the four-state area between the fruit growers and the rest of the population. Finally the fruit growers formally deactivated but merely took their criminal seeding activities underground. With spite, they continued to carry out cloud seeding more intensely than ever, trying to eliminate all agriculture in the area, and to retaliate against those who thought law and order was part of our democratic society. Legal briefs are now being prepared for a giant damage suit against the three entities involved.

The federal government, thinking the fruit growers would abide by their commitments, began their own program of weather tampering in the four-state area. The Corps of Engineers wanted to lace the Potomac with giant dams for the creation of stinking mud flats. How else could the citizens of the area be convinced that they needed worthless dams and wouldn't it be much easier to enforce giant land acquisition projects when the population is economically depressed. Cloud seeding has continued ever since on a year-around basis. Results of this irresponsibility of cloud seeding is devastating. The target areas have been experiencing ten-inch rainfall deficits annually. Certain areas of the five states have become virtual deserts. Air pollution has increased to extremely high levels. Silver iodide, the seeding agent, is a highly poisonous carcinogenic and, as expected, cancer has grown by leaps and bounds. Emphysema and chronic respiratory diseases have become a galloping epidemic. Cloud seeding chemicals have burnt the foliage on the trees and eventually killing them. It has poisoned domestic animals as they eat the cultivated crops. Air inversions prevent an influx of fresh air, creating an atmosphere biologically incompatible with all living matter; in fact, ecological murder.

Another interesting item in the mid-Potomac, the government is trying to convince the citizens that they need a Potomac River Basin compact — a grand disillusionment of a new type of government. This compact will eventually eliminate the state legislators, the U. S. Congress, and finally

disenfranchise the people. Simply, the compact will enslave the people. Our government lackeys have found that cloud seeding is the ultimate for developing dejected attitudes, giving them a free hand to do as they please.

So severe is the pressure from the government that all news is censored, allowing only that to be printed that pleases the bureaucrats. This is not democracy, it is "dictatorship."

Accomplishments of Cloud Seeding

1. It was responsible for the great five-year drought in the northeast United States.

2. Isolated sections in the Northeast have experienced a feu 18 years of drought due to cloud seeding.

3. Weather disturbances in the south Atlantic have been eliminated and has reduced the east coast's rainfall by 30% – rain that is needed if agriculture is to be successful.

4. The average dairy farmer on the east coast, living in an area of cloud seeding has averaged a net financial loss of well over 1400.00.

5. Crop production in Franklin County, Pennsylvania, alone, has amounted to \$50,000,000.

6. When effects of seeding wears off, cloudbursts occur, causing floods, destroying crops, buildings, and drowning people as well as livestock.

7. It is responsible for the serious air pollution problems that exist.

8. Mental retardation and insanity are traceable to cloud seeding chemicals.

9. Poisoning of all living matter is directly related to cloud seeding.

10. Emphysema is three times higher in areas of heavy cloud seeding.

11. Cancer is virulently out of proportion.

12. Financial losses to agriculture and related industries run into the billions.

13. Forest trees as well as cultivated orchards are dying from chemical reactions taking place in the air due to the addition of cloud seeding agents.

14. Governmental employees have learned to be deceitful and fraudulent in dealing with the citizens of this country.

15. The atmosphere has been rendered completely biologically incompatible with all living matter, which includes animals, plants and humans.

Who Is In Favor of Cloud Seeding

Cloud seeding success is determined by its acceptance by the general public. Here is where we put the chips on the table. Under no circumstances has there been one report of anyone favoring this new underworld activity, unless greed is their goal. Congressional hearing, private studies, newspaper articles, etc., all ask the same request: please stop cloud seeding. The reasoning is quite simple, because seeding is grand larceny, international robbery and premeditated murder. Why should someone favor that which is total obliteration?

Wherever cloud seeding is conducted, it must be done with the will of the people. This is our democratic way of society. Is it democracy when we watch our crops wither and die from lack of rainfall because cloud seeding was used to stop the rain? Likewise, if a flood occurred downwind after a storm regathered? Do we have good democratic government when they encourage and conduct this type of crime? Why are a few big businesses allowed to hinder and trample the thousands that depend on nature? Why are they allowed to poison the very air we breathe, food we eat, and water we drink, hinder plant, animal and human life, and shorten the life expectancy of everyone exposed to this malignancy?

Cloud seeding apparently is another tool used to wrestle control away from the people with the eventual hope of enslaving them.

Addenda to Cloud Seeding as Seen in Franklin County, Penna., 1969

What of the seeding "sixties"? Cloud "seeding" is meant. Herewith the precipitation data by year:

1960 - 38.00"
1961 - 37.10"
1962 - 37.28"
1963 - 32.28"
1964 - 33.43"
1965 - 31.44"
1966 - 30.88"
1967 - 41.83"
1968 - 32.55"
1969 - 34.36"

The historical mean precipitation is 41.47". The above data being correct, there was a deficiency of 65.55" of precipitation for the decade! — better than a year and a half's rainfall!

This decade as far as those using the land are concerned could well be named the "searing" sixties because the agricultural interests of Franklin County, Penna. lost over \$100 million thru droughts during the growing seasons of the years.

What of the population of Franklin County, Penna. as a whole? Well, the sixties could well be named the "sickening" sixties, as cancer, respiratory ailments, emphysema and chronic illnesses increased faster than did the population.

For some years extensive cloud seeding operations have been conducted over various areas of the Soviet Republic (U.S.S.R.). Chemical agents used have ranged from lead iodide mixture to cement dust. Ground-based aircraft pyrotechnics, rockets and artillery shells loaded with chemicals have been the means of dissemination.

The following from the *Wall Street Journal* "Commodities" column 17-XII-69, quote: "Weather conditions in Russia this year have been described as more difficult than ever before," unquote. Again, *Wall Street Journal* — January 2, 1970 — quote: "Bad weather trimmed farm output: industries' annual gain slowed. A campaign to recover from a winter wheat disaster hurt the rest of the economy," unquote. Proof that cloud seeding disrupts normal weather patterns.

The ecological effects of weather modification: A problem analysis sponsored by U. S. Department of Interior - Bureau of Reclamation, Office of Atmospheric Resources, May 1969. Quote: "Fog dispersal agents may have detrimental effects on plants and animals over a long period. As a matter of public policy, aerial distribution of unknown proprietary compounds should not be allowed on any but a strictly experimental basis, even if tests convince health agencies that the materials pose no immediate threat to human welfare. Full disclosure of the composition of any such material added to the environment is necessary in order that the scientific community as a whole may evaluate the possible long term effects," unquote.

Benefits of Cloud Seeding

The only known benefit to be accomplished through heavy seeding of clouds will be the control of the population growth. Adolph Hitler did the same thing by the use of gas chambers.

Havoc

Unless cloud seeding is brought under control, total disaster lies ahead. This is made manifest by the distinguished scientist Gordon J. F. MacDonald in his "How to Wreck the Environment: Geophysical Warfare," in *UNLESS PEACE COMES*. Thus it is that over 25 years of massive and repeated attacks on natural weather coincides with dislocation of the atmosphere so grievous that the world's weather is "going crazy." And this "crazy weather" has played a major role in food shortages, as Secretary of the Treasury Shultz noted. Naturally, the explosion of food prices has become "a terrible drama." So desperate is the situation that the world is now reduced to dependency on a single season's weather. The situation is "precarious" and "intolerable."

Small wonder. Hosler of Penn State admits that "tons" of seeding chemicals are, as he puts it, "spewed" over us in a decade. In one specific instance, typical of the rest, "eight tons" of nucleating chemical — seeding agents — were seeded over the Punjab, India, 16 July to 18 Sept., 1954. In this case, as in the Rapid City Disaster, the hygroscopic, common salt, was used. Salt expands enormously in these experiments, more so than the poison commonly used, silver iodide. Salt and soapstone were the seeding agents used over the Indian sub-continent. Result? Disastrous floods.

Closer home, we have the evidence of Hurricane Camille (1969), Agnes (1972) and Brenda (1974). In fact, the Government spokesmen admit seeding hurricane Debbie, "massively," on 18 and 20 August — the precise dates on which Camille revived, intensified, turned inland, and set off unprecedented havoc. Ample warning of what would happen if seeding were done in the Gulf, as it was, was given years ago by Irving Langmuir, Nobel Prize-winning scientist of General Electric, and a founder of weather modification:

The intensive hurricane seeding off the USA coasts by USA military and USSR military during the summer just passed, 1974, has apparently resulted in the suppression of hurricanes. This is a most dangerous game, since hurricanes have long been known as essential distributors of excessive heat from the tropics to the northern temperate zones. Moreover, hurricane "modification" (suppression) may result in a forty percent (40%) reduction in precipitation run-off! The result would be "water shortages comparable to those of the recent droughts in the northeastern states." Seeded rains

are "rains of low intensity, small drops, and little or no runoff." Result: "marked ecological changes in the microclimate — grass becomes dry and dormant, surface temperatures are elevated, relative humidity in the lowest layers is depressed, insect eggs fail to hatch, etc."

It has been reported that hurricane research has been moved to the South Pacific. Is it coincidence that Darwin, Australia, was wiped off the surface of the earth?

Beer vs. Food

On 5 and 6 March, 1973, hearings were held at Alamosa, Colorado, on the petition of Atmosperics, Inc., of Calif., to seed the San Luis Valley for Coors Brewing Co. & Valley Growers, Inc. The purpose: suppress hail and "increase" rain. The evidence that the suppression of hail means suppression of rain as well (as Hosler of Penn State warns), and therefore drought follows, was so clear that the petition was denied. Thus the 85% of area population who were on record as against seeding were given respite from disastrous man-induced drought.

The testimony of Charles B. Moore, Professor of Atmospheric Physics, New Mexico School of Technology, Secoro, N. Mexico, was crucial. Seeding is no way to modify the weather, he said. The amount of poisonous silver iodide used is "appalling" in its effects. If modification is desired, electrical charges should be used, following nature. Intense rainfall follows after lightning; lightning is the best "rain-maker" there is.

The amount of seeding proposed for this valley would be a catastrophe, he said. Also, the "rainfall" shown on radar as tiny droplets would be recorded as precipitation. In fact, the dry air evaporates such drops, and none reach the ground. In addition, rain cannot be "made." Seeding decreases rainfall well beyond the target area. So, seeding the Tuscon, Ariz., target area, results in an apparent 49% loss of rainfall. Down wind, in Walnut Gulch, there was also significant decrease in rainfall. Moore agrees with the distinguished hydrologist, Dr. H. B. Osborn, that seeding accounts for a 34% loss of rainfall. It can never, said Moore, be predicted that the seeding chemicals will remain in the target area. It also appeared in the testimony that whoever reads and reports the rain gauge record controls the data. Such a person's honesty controls the record.

A recent report from the San Luis Valley states that the Valley Growers, Inc., are growing more barley than ever, paid more for it, to not have to store it and have not had to pay out \$100,000, the fee for cloud seeding. Tom Henderson of Fresno, Calif., was applying for a permit to seed the Valley for the growers by demand from Coors! He fraudently applied on basis of rain-making although Coor's admitted, under oath, that drought was the desired result. Coors' only contribution to society is the production of an alcoholic beverage — alcohol, our greatest drug abuse problem.

Dirty Tricks

Twenty-six aides and assistants of Richard Nixon have been imprisoned and/or fined for their part in "Watergate." Yet these men are absolutely "pure" compared to the syndicated mob engaged in weather manipulation, as well as those covering up for them. Pennsylvania must lead the list. The

State requires a license for all doing cloud seeding, which must be obtained from the State Weather Board, operated by the Secretary of Agriculture. This Weather Board has never functioned. The Secretary of Agriculture, under both the Republican and now the Democratic administration, refused to enforce the statute as required by law. They have used the State Police to harass the citizens; blackmail schemes have been used; press releases of outright lies have been passed out to the entire State and, in general, these men have made clowns of themselves. These governmental agencies have all participated in the cloud seeding cover-up that is going on throughout the entire year: Department of Agriculture, Bureau of Aviation, Federal Aviation Agency, Federal Bureau of Investigation, the Pennsylvania State University, and every branch of government at the federal level who are engaged in weather manipulation. Since agriculture suffers the greatest damage from cloud seeding, they are the ones who receive the greatest ridicule. Government's opinion of agriculture is: it is a minority, it is unnecessary, unwanted, pollutes the streams and fouls up the air, so let's get rid of this industry.

Information released to the public on cloud seeding results are rarely true. If decreases of rainfall are achieved, the public is told that rain is increased. If hurricanes cause untold damage, the government denies seeding. In the Rapid City flood, three members of the cloud seeding community made a study, reported that seeding was not responsible, but the facts show that cloud seeding was the absolute cause of the terrible flood.

When the citizens of the United States are not correctly informed on cloud seeding results, maybe the time has come to have all cloud seeding stopped until rules and regulations are enacted to govern all weather and climate modification.

Screwball Weather

The intricate complexities and unknown dangers, especially of irreversible changes involved in cloud seeding, demand carefully monitored local, small-scale operations. To date, this remains unheeded.

That this is no idle threat is revealed by the fact that "silver iodide is toxic and must be handled with care." Yet tons of this poison are dumped over the country in a decade, as Charles Hosler, Penn State Meteorologist, admits in his pamphlet "Why is it Dry?" The distinguished cloud seeder, Irving P. Kirck, notes that "The Government will be putting out thousands off pounds of seeding material, and we put out one-fifth of an ounce per hour. That shows how little you have to use . . . The Government thinks it can do more by using more." Kirck calls such folly "screwball situations." In spite of dangers, known and unknown, "It is highly unlikely that seeding with silver iodide will be abandoned." Charles B. Moore, Professor of Atmospheric Physics, New Mexico School of Technology, says that no one really knows how long seeding chemicals stay around, and that the amount used is "appalling."

One of the worst droughts, that of the entire region of Sub-Sahara, a catastrophe unprecedented, lasting seven years, coincides with intensive seeding in Kenya for the Tea Industry. Seeding chemicals are effective for many hours, and hundreds of miles; the Trade Winds, easterlies (flow east to west), carried these agents of death over that fragile ecology. The drought killed countless thousands, and ruined the economy of the nations. The tea crop has never been better. Small wonder Maurice Strong, head of

the U. N. Environmental Program, warns that theft of rain could lead to world battle. Time is running out.

It is fairly well known that this past summer's (1974) mid-west drought coincides with the annual and massive cloud seeding programs in the Rocky Mountain States. Not so well known is the fact that after any huge seeding program, or even a modest one, the chemicals that are not used up will move clear around the globe and trigger effects that are completely unpredictable (see "Gov't. Weather Tampering is Causing World Floods," in *THE NATIONAL TATTLER*, Chicago, 24 Dec., 1972). Flood and drought are the inevitable companions of WM. Global bad weather is forcing farm prices sky high. Severe droughts are causing not only severe global food shortages from crop failures; moreover, the slightest change of a degree or two in ocean temperature off the coast of Peru started a chain reaction that practically wiped out commercial fishing there.

South Dakota

The enclosed "Letter to the Editor," printed in a local newspaper in South Dakota, summarizes the rain-making in that state. Most areas were 7-8 inches short in rainfall during the growing season since cloud seeding started.

To the Editor:

Being a farmer-rancher on the north Buffalo County line, I have watched weather modification for several years. We got more rain than they did under their modification program until the plane started to fly farther north. Many times I have seen what looked like a rain cloud coming, until the plane went through it, and then the cloud would promptly disappear. They also had several bad hailstorms go through Buffalo County during their modification program.

If modification would produce one-to-two inches more rainfall, I suppose we might have a chance to win ten-to-one, but what if we lose one or two inches of rainfall or more? It looks to me like another smooth-talker has made suckers of us.

Last year we had the driest spell I've seen for a long time, from June 4 until August 18 we had about three-quarters of an inch of rain in small showers, not enough to help much. We had clouds that looked good but the rainmakers flew through and took care of them.

The rainmakers quit August 15, and on the 18th we got a half-inch of rain. About the 30th we had three inches and a rather wet fall from there on out. This, of course, could be coincidence or just plain South Dakota. But I think we should save our hundred thousand-two million dollars a year to help the drought-stricken, because even with the Chamber of Commerce, counties and state financing this modification program, under South Dakota's present economy agriculture will finance at least 50 percent of it.

The Rapid City, S.D., disaster of 9 June 1972, was an unprecedented flood which cost 250 lives and destroyed \$100 million worth of property. Intensive research by *Environmental Action* of Washington, D. C. (see issue for 12 May '73) shows that the five runs of seeding storm clouds with salt apparently turned them into four huge rain generators held stationary over the victimized area for hours. So great was this man-induced

deluge that the record shows "*more than ten times the flow of any previous flood on record*" for that area. The article suggests that the steadfast denials of responsibility by the seeders (S.D. School of Mines, Inst. of Atmospheric Sciences, the federal Interior Dept., commercial seeders) comes from their "determination to convert our skies into their own experimental laboratories." This results of course in "their self-serving twisting of facts and conclusions," which smacks "of nothing less than a meteorological Watergate." Thus the conclusion of Britain's leading meteorologist, Dr. Brian J. Mason — "The last twenty years of effort in cloud seeding have been a waste" (SCIENCE NEWS, "Earth Sciences," vol. 97) — is the understatement of the decade. The Stockholm Conference on the Ecology of 1973 concluded that the three greatest dangers to the survival of man are SST, the dredging of rivers, and at the top of the list: Weather Modification.

Recommendations

It is recognized the United States must continue with weather modification research to find out what should be controlled and what should be left to nature and how to protect the country militarily.

However, the cloud-seeding community have been too indifferent of the people's welfare, both health and economic, and too careless of their responsibility to take scientific precautions to protect the people, the economy, the ecology, and the global atmosphere against adverse effects of weather modification.

Therefore, Congress should establish a federal regulatory body that regulates the traffic but does not manage the scientific activity. In fact, the Commission should be expressly forbidden to engage in any aspects of management.

The chairman and one-half of the Commission members should represent the public interest in view of the overwhelming concern, interest and investment in the geographical area as compared to the cloud seeder's slight financial and emotional interest.

An advisory body composed of scientists of every discipline should be maintained on a permanent status as a "watch-dog" over cloud-seeding activities. They should be required to look for possible damage to the economy, the public health, the ecology, the global physics and to search for international methods and practical methods to insure against foreign control of the nation's weather.

This is a large federal employment project, but the damage is far more serious. To restore the citizens' confidence in the federal and state governments, every cloud seeder should be required to register with the Federal Commission and to pay the costs to the Federal Commission of advising the County Commissioners of every county affected, of the project, of its nature and its duration and of inserting a public notice in one newspaper in each county. Cloud seeding in any agricultural area should not be permitted more than one-fifth period of time of the total growing season, as the possibility of increasing rain appears dim at this time.

The Tri-State Natural Weather Association requests the President of the United States to announce a ban on all cloud seeding on or over the Appalachian Mountains and the Atlantic Coastal Plain for three years or until the federal regulatory commission is established, to permit the economy to recover.

Any failure to announce such a ban publicly will be recognized as a verification the federal government considered and planned the destruction of the agricultural economy on the East Coast and eventually, of the people.

Additional copies of this pamphlet are available upon request. Please include fee to cover costs.

—OO—

Your help is **NEEDED** to expose the tyranny of cloud seeding. Financial contributions will be accepted and greatly appreciated.

Please send to —

TRI-STATE NATURAL WEATHER ASSN.

Route 1

St. Thomas, Pa. 17252

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"CLOUD SEEDING"
The Crime of the Century

1957. Blue Ridge Weather Modification, Inc., a group of irrigating fruit growers, began cloud seeding. The purpose was to destroy all summer cumulus storm systems because of hail and wind damage. They did not need rain because winter run-off was used as a water source to irrigate. Rainfall deficits ran from 7-10 inches each year with the greatest deficiencies in the target or protected area. Directors one of the years were H. W. Miller, Fred C. Matson, Paul M. Hawkins, Henry Heisey, W. W. Hunt, Edward Hepburn, A. Tom Machemer, E. W. Lins, Alfred Snapp, Turner Ramey, Gerald Edwards, Fred Glaze, John Rinehart, E. A. Leatherman, J. Kenneth Robinson. Due to eroded relations with their neighbor farmers, this group disbanded, went underground and have intensified the seeding operations. They have now concluded 18 consecutive years of seeding.

This group has managed to place members in key positions of government and farm groups, thereby stopping all efforts to regulate weather modification laws. Their efforts have created 18 years of unprecedented drought in the mid-Potomac or allied fruit belt. Losses to livestock and crop farmers have run into the billions and hundreds of farmers have been forced to leave agriculture. Regrouped weather patterns downwind are also overloaded with moisture and energy and now rampage, causing severe floods and high winds, and more damage.

Pennsylvania, Maryland, and West Virginia have passed laws to regulate cloud seeding or ban it entirely. Maryland banned the activity during the administration of Agnew. His position on law and order is well established, and, of course, there was absolutely no enforcement. Pennsylvania attempted to regulate rain making by law which is administered in the Dept. of Agriculture. The Pennsylvania State University heads up research in cloud seeding, so no enforcement has ever been attempted. West Virginia has attempted similar legislation with no results.

Pennsylvania has earned a reputation of lawlessness relative to cloud seeding. The past two secretaries of agriculture have both stymied all efforts to regulate weather manipulation. The Pennsylvania State University has engaged in blackmail activities against those who want the law enforced, have conducted research in contempt of the law and lied about the outcome of their own results of cloud seeding. These various agencies have all helped to obstruct law enforcement in the state of Pennsylvania: Department of Agriculture, Bureau of Aviation, Federal Aviation Agency, Federal Bureau of Investigation, the Pennsylvania State University, and all branches of federal government, who have or are doing cloud seeding work. A meteorological Watergate!

Two projects of cloud seeding conducted by Charles Hasler of Penn State were Project Showers and Cloud Buoyancy — fancy titles to deceive the citizens, but both were to destroy cloud growth. Project Showers resulted in extreme drought in the seeded as well as downwind areas, but the Cloud Buoyancy project resulted in no rainfall in the target area. Both of these experiments have been put to use by the fruit industry.

Fruit produced in areas where this type of seeding is used have produced a crop exactly as the fruit grower wants. It is not too big, packs easily and is handily shipped. It does take a spray to make it color. The fruit is hard as stones and is not fit for human consumption.

Governor Shapp, when running for the office and in need of votes, made the enclosed statement: "Be assured as Governor I shall insist that all the laws of the Commonwealth are vigorously enforced. I shall most certainly insure that there is strict enforcement of the laws controlling cloud seeding. Also, as Governor my door will be open." After being elected, Shapp closed his door, boarded and padlocked it, and then put pressure on the Secretary of Agriculture preventing enforcement of the law. Shapp also prevented appropriations from being channeled to the weather board.

Government's opinion of agriculture apparently is as follows: It is a mini-minority, it is not necessary, it is not wanted, it pollutes the streams, smells up the air, so let's get rid of it, and the sooner the better. This certainly is the case in Pennsylvania where laws are deliberately ignored and the government is behind this prevention of enforcement. Yet, Governor Shapp's representative attended the World Food Conference in Rome, telling how necessary it is to feed the hungry.

A recent statement on the position of the federal government certainly merits recognition. According to them, the federal agencies involved in cloud seeding need not abide by laws that have been passed to regulate cloud seeding. So eroded and decayed is their integrity that lawlessness and disorder have become a way of life. Without question, the citizens of the United States are now the enemy of the Defense Department as they use us to practice weather warfare maneuvers. They have no concern of crop loss due to drought or downwind floods or of the economic plight placed upon agriculture.

In the words of a Penn State professor, the farmers of Pennsylvania should be proud to have the University tamper with the common property of the citizens. The farmers should be proud to see their crops wither and dry up from drought caused by cloud seeding; they should be proud to watch their cattle starve and stop producing; they should be proud to see their families be denied the necessities of life and eventually see their farming operations forced into bankruptcy. Is it any wonder that Congress has been sued for founding the land grant colleges because they have been doing research that is detrimental to mankind?

Lightning suppression is one of the major aims of the weather manipulation syndicate. According to them, it is to prevent forest fires, yet only 20,000 fires are caused by lightning each year, out of a total of 125,000. This again is a scientific blunder because lightning is necessary to release nitrogen to be used as fertilizer in crop production. At least one hundred million tons of nitrogen are made available each year by lightning. With the extremely high price of commercial fertilizers, nitrogen is now more important than ever. This is one more giant stride in eliminating the farmer, and the cloud seeding mob has always tried to slick up their activities by portraying themselves as rain makers. The news media is continually bombarded by the propaganda from the cloud seeders. To date most of the news people have been unable to see through this smoke screen. Probably Lane Palmer, of FARM JOURNAL, must wear the dunce's cap for ignorance revealed in articles printed by his nationally circulated magazine. This person has continually refused to acknowledge facts presented to him, that shows tremendous rainfall deficits in seeded areas. Also, many places have floods hundreds of miles downwind and during dry cycles, drought will continue for thousands of miles downwind.

Some of the areas where cloud seeding has inflicted tremendous damage to the environment as well as the economy of the country are listed as follows:

1. Sub Sahara drought, an unprecedented catastrophe coincides precisely with the intensive seeding for the tea industry in Kenya. Trade winds flowing east to west carry the remnants of destroyed storms over the fragile atmosphere, where it is too dry for the storms to regather. Tom Henderson, of California, is the cloud breaker.

2. Hurricane Agnes was piled up and stabilized over the mid-Atlantic region by heavy seeding under the direction of the Defense Department. With moist air coming in from the south Atlantic, as well as from the prevailing westerlies, the atmosphere soon became overloaded and a flood resulted.

3. Barley growers in the San Luis Valley, Colorado, were forced to use cloud seeding to stop rains, by demand from Adolph Coar's Brewery. Water must be put on in the spring and then no more moisture is wanted, so the beer is of "better" quality. Coar's only contribution to society is the production of an alcohol-type product, the greatest drug abuse problem we have in the United States. Is alcohol more important than food?

4. Rapid City, S.D., is the area where 250 people were drowned due to massive seeding that stabilized the prevailing winds. With the atmosphere stagnated, warm, moist air flowing into the area piled up, causing this terrible catastrophe.

5. Two-thirds of South Dakota is under a program of hail suppression. Many areas of the state report that they have had only one-half inch of rainfall from mid-June until October during the summer of 1974. Again, a case where the government promised great things for the farmers, only to find out that these promises were nothing more than lies. In this case, the grain farmers did not want rain during the heading and harvest season.

6. Let us not forget the 18 consecutive summer droughts in the mid-Potomac, supposedly for the benefit of fruit growers and their hail insurance carriers. This is just a partial listing of the hundreds of cases of disaster inflicted upon areas of the earth, absolutely the direct results of insidious weather tampering.

Even Russia is aware of the immense efforts by the United States to control the weather. They also realize that the damages far exceed any benefits that could result from manipulation. Since other countries become involved, the problem is of international significance. With this in mind, Russia appeared before the United Nations requesting that weather warfare be banned as a weapon of aggression.

In a report from Russia, some clouds of the type forming during the summer months, rainfall was increased, but most of the clouds seeded showed a large decrease. The increase in rainfall from such clouds account for no more than one percent of the total rainfall. The chances of increasing precipitation from winter clouds over mountainous regions appear to be greater than are the chances of getting increases of precipitation from summer showers and thunderstorms.

Cloud seeding is used to change the normal to something different. The conclusion of the Ecological Society of America and issued by the National Science Foundation simply states: "Living things are adapted to the weather that actually prevails and any change in that weather will be generally deleterious to them."

Ninety percent of all cloud seeding uses the material silver iodide. The material has been and is used by the tons each year. It is highly corrosive and toxic. Silver is a heavy metal, one that is most poisonous, a carcinogen, and it affects the mental as well as all biological functions of all animals.

Silver iodide is a material that changes cloud droplets into microscopic snow. Snow is the low energy form of a cloud system. When this happens, the rain making process stops, turbulence ceases and the cloud dissipates. To increase rainfall, cloud growth must be increased and the life of the cloud prolonged. Silver iodide does just the opposite.

There is no known commercial or research work being conducted now or that has been done in the past for the purpose of increasing cloud growth or prolonging cloud life on summer cumuli, the only possible way rainfall can be increased.

Defense Department aircraft work all weather patterns in mid-Atlantic states. One section of heavy concentration is the southern tier of Pennsylvania; according to the Federal Aviation Agency, there are as many as 160 flights in a twenty-four hour period. These aircraft disperse ice nuclei at almost infinity concentrations and inject it into the atmosphere, starting 24 to 48 hours before weather patterns move into the area. This seeding will dissipate almost all summer cumuli storms. In the winter, snows are changed into rain with the possibility of some increase of precipitation. This additional winter rain helps make the annual precipitation record look decent. However, rain during the winter leaches the soil of fertility and severely erodes crop fields. Snow is so desperately needed for a cover to prevent this damage as well as protection to prevent heaving of perennials such as alfalfa.

Hurricane research has been conducted every year since 1957 with some preliminary activity even before then. Some years, hurricanes are prevented from forming; other years seeding takes place after they have become giant tropical disturbances. Preventing their formation keeps 30% of the rain off the east coast, as happened from 1962 to 1966 and 1974. Global damage is far greater when seeding mature storms. Due to the massive damage created by seeding, particularly Honduras, hurricane research has been moved to the Pacific during the winter of 1974-75. Is it a coincidence that Darwin, Australia, was wiped from the map by an unprecedented cyclone?

Rain making in Indochina by Defense Department from 1967 to 1972, as might be expected, did not increase rainfall. What did happen was the stopping of rain in one area and piling it up in another. Heavy floods to wash out roads and bridges in one area while another section was left high and dry. As 25 years of attempts report, rain cannot be increased, only moved around.

The opinion of Tri-State is that all cloud seeding in the United States must be immediately stopped, until Congress passes legislation that will regulate all cloud seeding, both commercial and all branches of government.

Twenty-five years of intensive cloud seeding has proven the following:

- (1) Seeding during wet periods creates terrible downwind floods;
- (2) Seeding during dry cycles creates deserts; and
- (3) It creates havoc with all normal weather phenomena.

NATURAL RESOURCES DEFENSE COUNCIL, INC.,
Palo Alto, Calif., June 7, 1976.

Mr. FRANK R. HAMMILL, Jr.,
*Counsel, Committee on Science and Technology,
U.S. House of Representatives, Washington, D.C.*

DEAR Mr. HAMMILL: Thank you for your letter of May 21 requesting our views on the planning and management of a national weather modification effort. We have a strong interest in weather modification as regulated by the federal government and appreciate the opportunity to present our views to the Committee. Our major concerns are set forth in the enclosed papers: a statement to the Domestic Council (May 27, 1975), and a speech before a recent American Meteorological Society Conference (November 13, 1975). We hope that these materials will be useful to you and the Committee in your ongoing deliberations.

Our major recommendation concerning the regulation of weather modification activities at the federal level is to combine all research efforts in a single agency that will not be involved in future operational programs. We suggest that either NOAA or EPA be the lead agency in overseeing the research effort in weather modification. We strongly believe that the Bureau of Reclamation is the wrong agency to be conducting weather modification research. The Bureau has an obvious institutional interest in promoting, and administering, a large-scale operational program that may interfere with the objectivity of its research activities. Furthermore, the Bureau's inability to conduct a high-quality research program to date suggests that a Bureau administered program would continue to lack widespread credibility.

If we can be of any further assistance, do not hesitate to call on us.

Sincerely,

TERRY R. LASH, Ph. D.,
Staff Scientist.
JOHN D. LESHY, Esq.,
Staff Attorney.

Enclosures.

STATEMENT OF THE NATURAL RESOURCES DEFENSE COUNCIL, INC.

(By John D. Leshy, Staff Attorney for Natural Resources Defense Council, Inc.)

CLOUD SEEDING, PUBLIC POLICY AND THE ENVIRONMENT:
AN ENVIRONMENTALIST'S VIEW

I am speaking today on behalf of both the organization I work for, the Natural Resources Defense Council, Inc. (NRDC), and the Sierra Club. Both are activist conservation organizations, dedicated to promoting the broad goals of the environmental movement. I wish to emphasize at the outset that my remarks should not be taken as reflecting official Sierra Club policy on weather modification, for the simple reason that the Club has not yet adopted a policy on the subject. (I understand that the Club is now in the process of formulating an official position.)

The growing discussion and debate over cloud seeding—or deliberate precipitation augmentation, as our more learned friends call it—is welcome primarily for one reason. Because we are still only on the brink of a massive commitment to this technology, we have an excellent opportunity to assess fully the environmental and socioeconomic impacts of such a commitment before it is made. Cloud seeding has of course been around for nearly 30 years (and in fact was perhaps even more widely employed in the 1950's than it is now¹)—nevertheless, few would argue with the proposition that, at least if agencies like the Bureau of Reclamation have their way, we will soon grow dependent on some measure of cloud seeding to supply water for our basic needs.

In our society, technology assessment has traditionally been only haphazardly performed, if at all. Perhaps the most striking fact about the last two hundred years of incredible technological change is how little we evaluated or appreciated in advance the impacts, and especially the environmental impacts, of widespread application of a new technology. Could Henry Ford have predicted

¹ An estimated 10 percent of the land area of the United States was under commercial seeding operations by the early 1950's.

in 1910 that our cities would be smog-laden as a result of automobile-induced air pollution? Similarly, did anyone really appreciate in advance the impact of nuclear weapons testing, supersonic aircraft or chlorofluorocarbon aerosol propellants on the upper atmosphere, and particularly the ozone layer? Was the persistence of toxic chemical pesticides in the food chain predicted by anyone before these chemicals were widely promoted and used? It can be persuasively argued that our environmental crisis is largely the result of misapplication and over-application of various technologies.

One of the most important if little noticed effects of the National Environmental Policy Act of 1969 (NEPA) is that it provides the mechanism for accomplishing such an environmental assessment of new technologies like cloud seeding in advance of their widespread application. This was clearly brought home by the decision of the federal Court of Appeals in *Scientists' Institute for Public Information v. AEC*, in which I am proud to say, an NRDC attorney represented the plaintiff. In that case the Court of Appeals rejected the AEC's argument that a comprehensive environmental impact statement was not necessary on its Liquid Metal Fast Breeder Reactor Program.

In an often eloquent opinion which rewards a careful reading, the Court dealt at some length with the role of NEPA in this context. Parts bear repeating here: ". . . Development of the technology serves as much to affect the environment as does a decision granting a construction permit for a specific plant. Development of the technology is a necessary precondition of construction of any plants. * * *

When Congress enacted NEPA, it was well aware that new technologies were a major cause of environmental degradation. The Act's declaration of policy states: 'The Congress [recognizes] the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of * * * new and expanding technological advances * * *'

And the Senate report notes, as one of the conditions demanding greater concern for the environment: 'A growing technological power which is far outstripping man's capacity to understand and ability to control its impact on the environment.'

NEPA's objective of controlling the impact of technology on the environment cannot be served by 'all practicable means,' unless the statute's action forcing impact statement process is applied to ongoing federal agency programs aimed at developing new technologies which, when applied, will affect the environment." 481 F.2d 1109 (D.C. Cir. 1975).

I am not now prepared to say that cloud seeding technology poses the environmental threat that I believe the breeder reactor does; nevertheless, it does involve uncertainty and risk. While the long-term effects may be difficult to pinpoint—given the fact that the yield claimed to result from most cloud seeding is less than the normal variation in precipitation in any particular locale—one very important lesson we have learned in environmental impact evaluation is that nature reacts subtly but profoundly in ways we find hard to predict. For example, among the issues I'd like more information about are the following:

(1) What are the long-range impacts of consistently heavier precipitation on the flora and fauna in the affected area? For instance, are occasional dry periods or wider fluctuations in precipitation required for the maintenance of adequate supplies of food for some migrating species such as elk and bighorn sheep? The question is important because generally plant and animal structure and life respond to average climatic conditions. Increase in the average precipitation means inevitable, if slow, adjustment over time.

(2) Similarly, what are the long-range impacts of a higher average snowpack or rainfall on soils and landforms? Because substantial cloud seeding has taken place and evidently will continue to take place over wilderness areas, this question of long-term impact on wilderness areas is a particularly important one. This concern is emphasized because the very legality of such activities within the strictures of the Wilderness Act may depend on an assessment of their long-range impact.

(3) What are the long-term environmental effects of the silver iodide or other agents used to increase precipitation? Can free silver—a highly toxic substance, especially to fish—be formed by the action of soil microorganisms over time, as is suggested by some recent research, or is the dispersion of relatively large quantities of silver iodide benign, as some proponents assert? In particular, what are the cumulative effects over time? Certainly our experience with DDT, lead, mercury, sulfur oxide, and other chemicals applied or released to the environ-

ment in large amounts over the past decades has not been reassuring. Again, the point is that nature often works in very subtle ways that we cannot fully appreciate without careful research. Indeed, my scientist colleagues tell me that even with careful research, serious adverse effects may not be predicted in advance. DDT may provide a case in point.

(4) Another area of concern is whether long-range downwind effects of cloud seeding can be measured and assessed. Most environmental impact reports I've read say something like "there is no evidence that" cloud seeding "captures" precipitation from more distant downwind areas. Such a negatively phrased statement can be extremely misleading and betrays a bias by refusing to discuss what evidence there is of any long-range downwind effects. This issue may be of special concern to the Rocky Mountain States in light of proposed new snowpack augmentation projects for the Sierra Nevadas. We need to know whether increased snowfall for California's Sierra Nevada means less for the Rocky Mountains.

Since we are not yet dependent on cloud seeding (nor will we be in the next few years even under the most optimistic forecasts), we now have the rare opportunity to design the studies, do the research, and make the evaluations which will give us the information needed to make better decisions about whether, where, when and how much to rely on cloud seeding. However, I want to make clear that the Bureau's proposed initiation of more so-called "pilot" projects may not be the best way to proceed in evaluating the crucial environmental issues mentioned above. Rather, greater emphasis must be placed on laboratory analyses and increasingly sophisticated modeling of ecosystems in combination with careful analysis of existing data on, e.g., migration of elk herds.

As I stated earlier, NEPA provides the authority and the mechanism at the Federal level to undertake these studies and assess these effects. While careful compliance with NEPA will not lay all these uncertainties to rest, it serves a very important purpose. As the Court of Appeals said in SIPI:

"Similarly, Section 102(C)'s requirement that the agency describe the anticipated environmental effects of proposed action is subject to a rule of reason. The agency need not foresee the unforeseeable, but by the same token neither can it avoid drafting an impact statement simply because describing the environmental effects of and alternatives to particular agency action involves some degree of forecasting.

"And one of the functions of a NEPA statement is to indicate the extent to which environmental effects are essentially unknown. It must be remembered that the basic thrust of an agency's responsibilities under NEPA is to predict the environmental effects of proposed action before the action is taken and those effects fully known. Reasonable forecasting and speculation is thus implicit in NEPA, and we must reject any attempt by agencies to shirk their responsibilities under NEPA by labeling any and all discussion of future environmental effects as 'crystal ball inquiry.' The statute must be construed in the light of reason if it is not to demand what is, fairly speaking, not meaningfully possible * * *.' But implicit in this rule of reason is the overriding statutory duty of compliance with impact statement procedures to 'the fullest extent possible.'"

Let me therefore turn to the implementation of NEPA on cloud seeding programs. I don't believe the record is, to state it bluntly, satisfactory.

The Bureau of Reclamation has been the lead Federal agency in promoting cloud seeding, and it has prepared environmental impact statements on some of its pilot programs. In 1973, under urging from the President's Council on Environmental Quality, it agreed to prepare programmatic EIS on its entire cloud seeding experimentation program. Believing that this "programmatic" EIS offers a unique opportunity to perform the necessary careful assessment of cloud seeding as a technology, we at NRDC have worked with the Bureau in reviewing preliminary drafts of the statement. We have been very disappointed both with the substance of those sections we have reviewed, and with the snail's pace with which the Bureau seems to be moving.²

I hasten to add that we do not expect the Bureau to perform, overnight, the kind of careful evaluation required; nevertheless, it is particularly disturbing that, in advance of that assessment, officials in the Department of the Interior have repeatedly invoked, and stated their intention to rely on, the promise that

² For example, in November 1973 we were told the statement would be released in February 1974; in April 1974 we were told it would appear late that spring; in September 1974 we were told November 1974 was the target date. One year later, not even the draft has been released.

cloud seeding holds to increase our water supplies for agriculture and energy development. Examples of such promotion are reflected in the following statements:

"Indications are that weather modification can be made operational in the Upper Colorado River Basin to provide a new water supply for beneficial use throughout the Basin." ("Water for Energy in the Upper Colorado River Basin" (Bureau of Reclamation, July 1974), p. 58.)

"Weather modification has moved from the experimental to the large field test stage. Weather modification techniques, it is believed, can add 1.5 million acre-feet, or up to 10 percent, to the annual flow of the Colorado River." (Speech by Assistant Secretary Jack O. Horton, Fresno, California, November 13, 1974.)

The Bureau of Reclamation's 1973 Annual Report (*Water and Land Resource Accomplishments*, p. 33) contains this rather audacious, if not totally accurate, description of the Bureau's cloud seeding activities in 1973:

"The legal, environmental, and socioeconomic aspects of precipitation management . . . have been studied. In 1973, work was directed more extensively toward the coordination and active participation by State and local interests to assure a smoother transition from research to operational application to maximize the scientific value of cloud seeding."

Given such statements, we cannot be faulted for suspecting that there is a deliberate effort by promotional agencies to build momentum toward greater reliance on cloud seeding, in advance of performing the necessary analysis of its impacts. Such one-sided touting of the technology is both dangerous and, we believe, inconsistent with NEPA.

Perhaps this is inevitable given the fact that the Bureau of Reclamation exists to promote water resource development. We cannot, I suppose, realistically expect the institutional bias to be eliminated in dealing with cloud seeding. For that reason, we have come to doubt whether the Bureau, or any other promotional agency, is the appropriate body to be conducting the kind of environmental impact assessment required. Rather, a new institutional framework is necessary.

Formation of a blue-ribbon interagency, interdisciplinary task force is one such approach. Reliance on the National Center for Atmospheric Research to conduct studies might also be appropriate. Another idea is to designate a single federal agency, other than one engaged in operational programs or promotion of cloud seeding, to organize and conduct cloud seeding research, to broaden information-gathering procedures, and to oversee federal and non-federal operational programs. The administration of cloud seeding activities in the United States has been too fragmented. Federal, state and local agencies carry on programs and conduct individual projects without awareness of the cumulative impact of each other's work. There has been no national focus for cloud seeding research and, most importantly, there has been no meaningful, comprehensive assessment of the potential environmental impacts of existing and planned weather modification programs.

We do applaud the Bureau's Mid-Pacific region for contracting with an independent assessor, Charles Cooper of San Diego State, to evaluate its methodology for its proposed Sierra Nevada snow augmentation project. The Cooper report made many valuable recommendations, and we hope they will be followed. By contrast, the Bureau's five-year "operational adaptation research project" in western Montana was an utter failure. It was so poorly designed and carried out that it could not be determined what the effect of the cloud seeding was.³

Another disturbing aspect of federal agencies' promotion of cloud seeding has been their blurring of the distinction between "research" and "operational" cloud seeding projects. We saw this most clearly in the Bonneville Power Administration's effort to seed clouds over the Bob Marshall Wilderness area in 1973. From 1966 through 1971, BPA funded a Bureau of Reclamation-conducted research program in western Montana. Then in the fall of 1973, BPA proposed an "operational" project which in fact was essentially identical to the previous "research" project. On closer analysis, we discovered that the previous "research" project was elsewhere referred to as an "operational adaptation research project" which was located in the western Montana area because of its potential for high eco-

³ Two measurement procedures were employed in this project, each of which was susceptible to an unknowable but highly significant error. Not surprisingly, the contractor chose the type of analysis that yielded the positive rather than negative result, but could only conclude that overall increases in snowpack were "suggested."

conomic yields rather than research.⁴ Apparently the only reason for the change in terminology was that there is more doubt as to the Bureau of Reclamation's authority to conduct operational cloud seeding programs than the BPA's. The message seems clear: if BPA does it, call it operational, but if the Bureau does the same thing, call it research. This manipulation of the distinction between experimental and operational programs solely because of legal constraints unhappily can only exacerbate the distrust already felt by environmentalists toward such thinly-disguised promotions.

The experimental/operational distinction raises another issue on which we have had some disagreement with responsible governmental agencies. The issue as we see it is this: should environmental impact assessments of experimental cloud seeding programs assess only the environmental impact of the experiment itself, or should it go beyond the experimental program to discuss, to the extent information is available, the environmental impacts of an operational program which could follow? We think the latter is clearly required by NEPA. The Court in the *SIP* case addressed this question as follows:

"To wait until a technology attains the stage of complete commercial feasibility before considering the possible adverse environmental effects attendant upon ultimate application of the technology will undoubtedly frustrate meaningful consideration and balancing of environmental costs against economic and other benefits. Modern technological advances typically stem from massive investments in research and development, as is the case here. Technological advances are therefore capital investments and, as such, once brought to a stage of commercial feasibility the investment in their development acts to compel their application. Once there has been, in the terms of NEPA, 'an ir retrievable commitment of resources' in the technology development stage, the balance of environmental costs and economic and other benefits shifts in favor of ultimate application of the technology. This explains why . . . the CEQ recommends: * * * In many cases, broad program statements will be appropriate, assessing * * * the overall impact of a large-scale program or chain of contemplated projects, or the environmental implications of research activities that have reached a stage of investment or commitment to implementation likely to restrict later alternatives. * * *"

As I noted previously, NEPA does not require doing the impossible, or completely anticipating the results of future research. But it does require reasonable forecasting, a careful discussion of all major problems that can be anticipated, and the assurance that identification of gaps in knowledge will lead the agency to do the necessary research before proceeding with an operational program. Indeed, anticipation of potential future impacts should be at the very heart of the NEPA review process. A useful result of this type of exercise is that major areas of importance will be highlighted and research programs designed accordingly.

Finally, I would like to call attention to the need of more analysis of the economic benefits of cloud seeding as a technology. Those of us who believe there is no such thing as a free lunch are understandably skeptical of claims that for a few thousand dollars worth of silver iodide and a couple of generators, millions of dollars worth of water can be produced.

Here again, the difficulties of measurement pose a formidable obstacle; i.e., given the gross variability of precipitation over any given area in any given year, how can we ascertain the effect of cloud seeding within acceptable levels? BPA's aborted cloud seeding project over Montana in 1973 taught us something here as well. At least in part because of protests by concerned environmental groups like NRDC over the hasty, ill-prepared effort, BPA cancelled the project in January 1974. A heavy snowpack accumulated naturally that year in the region—heavier than normal and heavier than was predicted. We can only speculate about what would have happened had cloud seeding been carried out, but it is worth some speculation. Flood damage with loss of property, possibly life, and ensuing legal liability is an everpresent possibility and ironically flood damage lawsuits can place cloud seeding proponents in the somewhat curious position of, in effect, denying the efficacy of the technology they promote, to avoid legal liability.

Have we really fully explored the alternative of conservation and more efficient use of water? What are the comparative risks, costs and benefits of a program

⁴ Interestingly, the environmental impact statement on BPA's proposed program nowhere disclosed that BPA funded the Bureau's previous "research" effort, nor did it reveal that the new "operational" program was essentially the same as the earlier five-year study.

of cloud seeding and a program of conservation? Doesn't reliance on cloud seeding merely postpone the inevitable day when we have to force ourselves to live within the bounds set by existing water resources? Here again NEPA has some wisdom for us, since it requires careful consideration of alternatives to the program under consideration.

CONCLUSION

On balance, I believe it appropriate that conservationists manifest a healthy skepticism—perhaps best expressed by the Sierra Club motto of “not blind opposition to progress, but opposition to blind progress”—toward widespread application of the cloud seeding technology at this time. There is much we don't know about its environmental impacts. Further, extreme caution is always a wise policy whenever it is proposed to tinker directly with natural forces as complex, ill-understood and ecologically important as the precipitation mechanism. And such skepticism is especially appropriate in this context in order to provide some balance against the unseemly enthusiasm manifested by some proponents of the technology.

Governmental agencies and officials should refrain from the uncritical promotion of cloud seeding as a panacea for water supply problems, at least until money is found to perform and evaluate the necessary research. Part of this effort should relate the potential contribution of cloud seeding to important social, economic and environmental goals. An overview environmental impact statement is a logical first step—preferably prepared under the aegis of the National Oceanic and Atmospheric Administration rather than the Bureau of Reclamation. Moreover, similar efforts could be proceeding under state environmental quality acts, like California's. Finally, carefully designed long-range studies such as those suggested in the Cooper Report must be initiated immediately so that meaningful results can be obtained and evaluated as soon as possible. As these things are done, we will be in a much better position to evaluate and make better, more responsible decisions about cloud seeding.

NATURAL RESOURCES DEFENSE COUNCIL, INC.,
Palo Alto, Calif., May 27, 1975.

Dr. RONALD L. LAVOIE,
Director, Environmental Modification Office, National Oceanic and Atmospheric Administration, Rockville, Md.

DEAR DR. LAVOIE: The Natural Resources Defense Council and Friends of the Earth submit this statement on federal aspects of weather modification in response to the announcement that the Subcommittee on Climate Change of the Environmental Resources Committee of the Domestic Council is reviewing existing federal policy and programs. (40 Fed. Reg. 18827, April 30, 1975).

Our major concern is with the direct and indirect adverse environmental effects potentially resulting from attempts by some agencies of the federal government to promote precipitation enhancement through cloud seeding. We refer primarily to the Bureau of Reclamation's efforts to encourage wide-spread cloud seeding over the mountainous and plain regions of the Western United States, but also generally to federal efforts to promote programs world-wide aimed at modifying weather conditions in order, for instance, to increase crop yields and to foster energy resource development.

To summarize the comments that follow, we believe that federal activity so far has been bureaucratically too fragmented. Furthermore, we believe that much of the federal research and analyses of the effects of cloud seeding have been of low scientific quality. Finally, we believe inadequate attention has been given to important environmental values that may be adversely affected by cloud seeding. In our opinion, a single federal agency, other than one engaged in operational programs or promotion of cloud seeding, should be designated to organize and conduct weather modification research, to broaden information gathering procedures, and to oversee federal and non-federal operational programs. Efforts should begin now to develop a regulatory scheme for operational projects.

The administration of weather modification activities in the United States is too fragmented. Federal, state and local agencies carry on programs and conduct individual projects without awareness of the cumulative impact of each other's work. Two National Academy of Sciences-National Research Council reports¹ and

¹ Committee on Atmospheric Sciences, National Academy of Sciences-National Research Council, "The Atmospheric Sciences and Man's Needs" (1971), —, "Weather Climate Modification, Problems and Progress" (1973).

several monographs² have described the great breadth of weather modification activities. This diversity arises in part from the several different objectives of these activities (which include hurricane modification, fog suppression and winter snowpack augmentation) and in part from the lack of effective federal leadership. Various agencies from the Department of Defense to the Bureau of Reclamation have conducted research for their own purposes, but there has been no national focus for such research.

Even more disquieting, in our view, is the serious lack of any meaningful, comprehensive assessment of the potential environmental impacts of existing and planned federal weather modification programs.³ As the authoritative report of the National Water Commission recently concluded: "[E]conomic, environmental, ecological, and other side effects [of precipitation augmentation] cannot yet be predicted reliably because of limitations in knowledge and practical experience." *Water Policies for the Future*, National Water Commission (June 1973), p. 349.

By designating a lead agency at the federal level for weather modification research and data gathering,⁴ there could be adequate supervision of all federally funded weather modification research and concentration of a staff of sufficient strength for continuous high quality research. It is unlikely that any other administrative arrangement would bring together the large staff of specialists from different disciplines required for designing the research, conducting it, and analyzing the data. Physical scientists, ecologists, social scientists, lawyers and statisticians are all necessary for a well-run weather modification research program.

Individual mission-oriented agencies such as the Bureau of Reclamation do not have these staff resources. They also may well be tempted to move into operational programs under the guise of "pilot projects" before the effectiveness and the environmental effects of weather modification are adequately established. The possibility of such improper actions could be reduced by designation of a non-promotional lead agency.

Furthermore, all entities undertaking deliberate weather modification, including military, federal and non-federal, should be required to describe major proposed activities completely and in advance to the lead agency. Statistical data in particular should be reported in full so conclusions can be verified. Any studies of inadvertent weather modification should also be reported. Encouraging states that have not already done so to establish their own permit systems should also be considered for projects under a federally determined threshold size.

By centralizing planning and control over research, areas of particular ecological fragility or concern, such as wilderness areas, can be protected. There is a substantial controversy over whether weather modification is legal in wilderness areas. There is also uncertainty over the long-term environmental consequences of such activities.⁵ Furthermore, some believe that cloud seeding over wilderness areas inherently violates the concept of wilderness and, therefore, should not be permitted even if adverse environmental effects do not occur. Both the controversy and the uncertainty underline the need for comprehensive information gathering and planning procedures. Since weather modification has yet to outgrow its research state, it is most appropriate that a research-oriented organization be involved in the decision making process when weather modification activities are contemplated over wilderness areas or in otherwise fragile environments.

² See, e.g., National Oceanic and Atmospheric Administration, U.S. Department of Commerce, "Summary Report: Weather Modification Fiscal Years 1969, 1970, 1971" (May 1973); R. G. Fleagle, et al., "Weather Modification in the Public Interest." University of Washington Press (1974).

³ For example, the Bureau of Reclamation's performance in assessing the environmental implications of its pilot programs has not been promising. The Bureau decided to prepare an overall environmental impact statement pursuant to the National Environmental Policy Act (NEPA) on its cloud seeding program in May 1973. Although a draft was completed in October 1974, it has still not been released. We recently had an opportunity to review part of the draft and found it of exceedingly low quality, failing to come to grips with many of the important environmental issues involved.

⁴ You are undoubtedly aware of the recent General Accounting Office recommendation that all weather modification research programs should be consolidated in a single agency. See, *Science*, Vol. 185, p. 1142 (September 27, 1974).

⁵ Among important environmental issues are the following: What are the cumulative environmental impacts of sustained additional precipitation on ecosystems, including fish, wildlife, soils and vegetation? What is the residual, long-term effect of seeding agents? What is the effect on water cycle and continental precipitation patterns, especially downwind; e.g., can cloud seeding "capture" precipitation which might have fallen elsewhere? What effect would precipitation enhancement have on flooding, erosion and sedimentation and what effects would this have?

As research indicates the need for particular pilot projects, the lead agency can work with mission oriented agencies, helping them acquire the capabilities required for a sound program. Existing pilot projects could be run jointly by the lead agency and the sponsor. No new pilot projects should begin without significant planning guidance and approval from the lead agency.

The National Oceanic and Atmospheric Administration (NOAA) has many of the legal responsibilities and technical capabilities for a lead agency in weather modification. Unfortunately, the Department of Commerce traditionally has not been generous in its support of research. Shifting NOAA to the Environmental Protection Agency (EPA) and designating it as the lead agency might make the best use of existing expertise and still secure the research orientation and environmental awareness required of a lead agency.

Since there are only a few operational weather modification programs at the present, some time remains to develop a regulatory scheme. Weather modification usually and perhaps inevitably has interstate effects; thus there seems to be no effective alternative to federal action. We recommend that the Committee consider vesting authority for operational weather modification projects in EPA. While new federal legislation which defines more clearly regulatory controls over operations may be necessary, we believe it is probably premature to seek legislation until the problems, through more and better defined research, are better understood.

In our opinion, decisionmakers in both the executive and the legislative branches presently lack the capability to assess the potential benefits and, more importantly, the environmental hazards of weather modification technology so that they may guide public policy concerning this growing activity. Deliberate weather modification raises difficult public policy issues in such sensitive and important areas as population, energy, and agriculture. It is extremely important that federal research and regulatory activities be kept free of special interest pressure and partisan political control. Research findings and operational data should be made public as a matter of course, and constant efforts must be made to involve interested experts at universities and public interest organizations in weather modification decisionmaking. We fully subscribe to the conclusion reached by a University of Washington study group:

"[D]ecisions respecting weather modification have so far been based on unrelated or even contradictory goals. Lacking any objective mechanism for deciding when a specific program of weather modification research should be expanded into an operational stage, this important decision has been left by default to the commercial market or to individual state or federal agencies. No coherent, sustained effort has been exerted to relate the potential contributions of weather modification to social or economic goals, nor even to direct technological development toward identified ends. Like virtually all prior technologies in a less sophisticated era, weather modification has so far been left to develop without explicit consideration of society's needs and values."⁶

Finally, we must point out that the international implications of weather modification are significant. Weather modification within the boundaries of one country or over the oceans may alter the climate in other countries, either purposely or inadvertently. In 1971, the Committee on Atmospheric Sciences of the National Academy of Sciences recommended that "A global network of monitoring and research stations should be established under international auspices," and urged the United States government:

"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."

We support this recommendation. We further urge that the United States do everything possible to assist in the development of internationally applicable general principles and operative guidelines on weather modification, and in particular that the United States support the efforts of the United Nations Environmental Program in this area.

Because deliberate weather modification has potential for subtle environmental destruction as well as catastrophic consequences, and weather modification projects in one form or another are already under way across the country, it is time for the federal government to formulate a weather modification policy with a supporting administrative structure.

⁶ Fleagle, et al., op. cit., p. 64.

We support the Domestic Council's interest in this topic, and we appreciate the opportunity to comment on the proper federal role in weather modification.

Please send us a copy of the Subcommittee's recommendation to the Domestic Council's Committee on Environmental Resources when it is made.

Sincerely,

TERRY R. LASH, Ph. D.
JOHN D. LESHY, Esq.

SKEPTIC,
Santa Monica, Calif., May 25, 1976.

FRANK R. HAMMILL, JR.,
*Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.*

DEAR MR. HAMMILL: Thank you for your letter of 21 May.

This is to inform you that within two weeks you will be receiving my statement for the hearings on H.R. 10039 and S. 3383.

For your reference, in the meanwhile, attached is a copy of a recent article of mine from the New York Times.

Your invitation to provide this statement is appreciated.

Sincerely,

LOWELL PONTE,
Contributing Editor.

WAR OF THE WEATHERS

(By Lowell Ponte)

SANTA MONICA, CALIF.—“From space one could control the earth's weather, cause drought and floods, change the tides and raise the levels of the sea, make temperate climates frigid,” then-Senator Lyndon B. Johnson told a joint session of Congress in 1957. Like many other legislators, he accepted Defense Department fantasies that the United States was in a race with the Soviet Union to develop environmental weapons.

Mr. Johnson as President made the fantasies real by ordering rainmaking in Southeast Asia. Between 1967 and 1972 he, and President Richard M. Nixon authorized at least \$3.6 million annually on secret cloud-seeding over North and South Vietnam, Laos and Cambodia in an attempt to muddy trails and slow enemy movements.

Although in one instance this enhanced rainfall by 30 percent, Pentagon officials call the operations a failure. But the Pentagon defends them as humane, saying, “Raindrops don't kill people; bombs do.” (The Department of Defense denies it was seeding over North Vietnam in 1971 when that nation suffered the heaviest rains since 1945. In 1945, a million Vietnamese died of flood and famine.)

Can a nation that tampers with natural balances deny responsibility for what follows? This question, together with recognition that United States policy condemns warfare aimed at civilians, prompted Senator Claiborne Pell in 1973 to introduce a resolution calling for an international treaty to prohibit environmental warfare “or the carrying out of any research or experimentation directed thereto.” The Senate voted 82 to 10 to approve the resolution, which lacks force of law.

Last August, at the 31-nation United Nations conference of the Committee on Disarmament, in Geneva, the United States and Soviet Union jointly proposed a draft convention to ban “military or any other hostile use of environmental techniques.” Unfortunately, it is far weaker than the Senate resolution. For example, it fails to prohibit military research or development of environmental-modification techniques, and allows all “peaceful” work on such things.

The Pentagon says its Climate Dynamics program, formerly Project Nile Blue, is peaceful and needed to detect Soviet attempts to disrupt North American weather. (Because the treaty appoints no inspection agency to enforce its ban, leaving nations to bring evidence of violations to the United Nations Security Council, treaty ratification would justify increased funding for Climate Dynamics monitoring.)

But Climate Dynamics researchers, using computer models of oceans and atmosphere, have studied ways to melt the polar ice caps, generate destructive storms, and otherwise use “key environmental instabilities” to release huge amounts of energy. They have found how the United States, acting secretly from space, could inflict bad weather on the Soviet Union, thereby ruining harvests and keeping that country dependent on United States grain imports.

In the Soviet Union, engineers are reversing the Arctic-flowing Pechora River and creating inland seas, actions that experts say will alter global climate. This is "peaceful."

In 1975, the National Academy of Sciences reported that cooling in the Northern Hemisphere since the 1940's makes the start of a new ice age within 100 years a small but real possibility. Scientists cannot determine whether the cooling is caused by humans or if one nation's bad weather is caused by another's weather-modification programs, so the potential for hostility arising from such programs is obvious. Global climatic changes will prompt many nations to use such modification techniques, but the world's unstable political climate demands that such techniques be internationally regulated, with adequate safeguards and with reparations for those who suffer drought or storm damage.

The draft treaty could be a step toward such regulation. But the treaty allows some weather warfare by prohibiting only techniques having "widespread, long-lasting or severe effects harmful to human welfare." What does this mean? The tiniest tampering with natural balances can set off chain reactions with unforeseen consequences.

Senator Pell and Representatives Gilbert Gude and Donald M. Fraser have proposed that all United States environmental-modification research—by civilians, the military and the Central Intelligence Agency—be put under Congressional control. Until this is done and the United States amends the draft treaty to eliminate loopholes and cloudy language, few nations will believe we want environmental warfare banned.

SKEPTIC,

Santa Monica, Calif., June 14, 1976.

FRANK R. HAMMILL, Jr.,
*Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.*

DEAR MR. HAMMILL: An untimely bout with flu has prevented my preparation of the full statement I hoped to provide for the Environment & the Atmosphere Subcommittee hearings this week on H.R. 10039 and S. 3383.

Instead herewith find a brief statement plus two chapters from my forthcoming Prentice-Hall book "The Cooling."

The chapter "The Lawless Sky" precisely addresses the concerns of the subcommittee, and I ask you to include it whole in hearings documents. The chapter "Weather, Climate, and War" deals with general issues of environmental warfare; you may reproduce it entire or excerpt it—perhaps from the mark on page 169 to chapter's end.

I think you and the committee will find this information of value. Thank you for inviting me to participate.

Sincerely,

LOWELL PONTE, *Contributing Editor.*

Enclosure.

STATEMENT

(Lowell Ponte until 1969 was a Department of Defense consultant on environmental and bizarre weapons for the International Research & Technology Corporation of Washington, D.C. He is now an editor of SKEPTIC Magazine and author of "The Cooling," a study of global climatic change and manipulation, to be published in July 1976 by Prentice-Hall, Inc. "The Cooling" includes a forward by U.S. Senator Claiborne Pell, chairman of the subcommittee on Oceans & International Environment, and a preface by Dr. Reid A. Bryson, climatologist and Director of the Institute for Environmental Studies at the University of Wisconsin, Madison.)

A growing body of scientific evidence now indicates that our planet's climate is increasingly unstable. This instability is manifest in odd weather extremes. As I write, drought is deepening in Minnesota and other regions of the Midwest. California continues to suffer from the worst drought in nearly a century. Efforts to enhance rainfall by cloud-seeding techniques have been stepped up dramatically in both California and Minnesota as a result.

The worsening world climate will prompt more and more such attempts at weather modification both in the United States and abroad—and indeed such technologies may prove a necessary hedge against global famine, nuclear proliferation, and war.

Scientists remain uncertain about the efficacy of such techniques. Cloud seeding one day may increase rainfall by 10 percent and on the next decrease it by a

like proportion—which may say as much about our primitive abilities to predict rain as it does about our ability to induce precipitation.

But H.R. 10039 and S. 3383 provide a reasonable framework in which experiments can be carried out to improve our understanding of weather processes and our ability to influence and predict such processes. Such legislation is long overdue.

The proposed laws, however, have some deficiencies, many of which can be deduced from Chapter 10 of "The Cooling," appended.

It disheartens me that all such experimentation done by or affiliated with the Department of Defense is excluded from the purview of H.R. 10039. Would this exclude from oversight operations like Project Stormfury, which have been co-sponsored by DoD? At present the Department of Defense maintains that it is conducting no classified weather modification research—so it seems reasonable that its Climate Dynamics (formerly Project Nile Blue) information and computer systems be opened to the panels charged with research and oversight under any weather modification legislation. Without knowledge of DoD activities, any picture of weather patterns will be inaccurate—because incomplete. Likewise, a better assessment is needed of regional weather and climate impact by new dams, factories, etc. I recommend that all DoD activities in this area and all environmental impact information acquired by the Environmental Protection Agency be ordered made available to your panels.

THE LAWLESS SKY

In April 1973 the Central American nation of Honduras officially accused the United States of theft. What had been stolen? Rain.

According to the Honduras Meteorological Service, the U.S. had "upset the balance of nature" by using cloud seeding and other techniques to modify hurricanes near Miami, Florida. For centuries moist Atlantic air has been carried by winds across the Gulf of Mexico, producing rain when stopped by mountains in Honduras. But now, said the Hondurans, the U.S. Stormfury Project was squeezing the moisture from this air. Thus the United States was responsible for the severe drought they suffered.

The protest seemed like the rerun of a movie that appeared in 1949, at the dawn of the global cooling trend. Drought struck the Sula Valley of Honduras. Between January and August of that year only 5 inches of rain fell in a region accustomed to as much as 100 inches. Grass withered, and cattle died of starvation.

But in a third of the valley rain kept falling, the third controlled by the U.S.-based multinational United Fruit Company. The reason: the company had a small airplane and a professional cloud seeder dropping dry-ice pellets into clouds over their plantation. In an article titled "Rustlers in the Sky," Time Magazine gave details of the native reaction, which included accusations of rain theft and cartoons depicting the company's Texan pilot herding clouds with a lariat.

To make peace, the United Fruit Company offered either to stop its seeding activities or to seed clouds over the entire valley. Local cattlemen chose rain, and a week later the first seeded clouds dropped an inch and a half of water, enough to seem a downpour on the hard-baked land. Pilot Joe Silverthorne was delighted. "Say the word," he bragged, "and I'll flood the country."

Twenty-four years later, as the Hondurans assailed Stormfury, the project was pulling up stakes to move to Guam in the western Pacific Ocean, where it was to begin seeding typhoons in 1976. Already the Japanese government has protested possible rain theft by Stormfury operations. Japan relies on typhoons to bring rain, and has asked the United States only to experiment with storms that will not reach land.

Thus Honduras got its way, even if in 1973 it got no help with rainmaking. Ironically, in September 1974 the small country was battered by one of the worst hurricanes in its history, FiFi, which caused 10,000 deaths and billions of dollars worth of damage. FiFi was precisely the kind of storm Project Stormfury was trying to control.

But was FiFi's devastation an accident of nature? No, charged the director of the geographic research center of the University of Mexico in July 1975. Jorge Vivo said he had evidence that the United States used weather modification that "artificially detoured" the hurricane to Honduras to save Florida's tourist industry. Thus, said Vivo, the U.S. should accept moral and financial responsibility for the disaster. The agency in charge of Stormfury, the National Oceanic

and Atmospheric Administration (NOAA), discounted these charges and said the United States had seeded no hurricanes since 1971. NOAA did not comment on whether or not other techniques the U.S. has tried in modifying hurricanes—coating sea surfaces in a storm's path with burning oil or with the anti-evaporation chemical hexadecanol—had been used against Fifi.

Hurricane Fifi destroyed most of the 1974 corn crop in Honduras. Drought returned to the small nation in 1975; by August it had killed 80 percent of the corn, and 700,000 Hondurans faced famine.

Ideally the Hondurans deserve a day in court, as do their neighbors in drought-stricken El Salvador who have made similar charges against the U.S., a chance to present any evidence they have that the United States has stolen their rain or directed a hurricane against them, a chance to gain justice for the wrongs they believe they have suffered. But this cannot happen, for at present there is no international law of any kind governing weather modification. In 1974 the United Nations General Assembly resolved that environmental warfare be forbidden, and a draft U.S.-Soviet treaty banning such warfare was put before the thirty-one-nation Disarmament Conference in Geneva in August 1975. Neither of these actions have the force of international law, however, and even if they did their application to Honduran complaints is farfetched. The U.S. and Honduras are not at war, and the U.S.-Soviet proposal excludes peaceful uses of weather modification.

But if law existed in this realm, Honduras would have a difficult time proving damages. The above cases illustrate some of the bigger problems future international lawmakers will have in regulating global weather and climate controllers.

Question 1. "Who owns the skies?" Centuries ago, most jurists held that the private owner of a plot of land controlled its soil to the core of the earth, its sky to the farthest edge of the heavens. He could shoot a goose flying overhead, or tap an underground lake beneath his claim.

With the advent of aircraft, new legal doctrines evolved to discourage would-be gunners who might shoot down airliners above their land, or charge tolls. Today's laws give to nations, not individuals, control of the "airspace" above their territory—a vague concept that includes most high-flying jets but excludes satellites. It seems to mean control to the edge of the atmosphere. And with large cities and ranches have come elaborate new doctrines of water rights, which apportion how much water from adjoining rivers, lakes, and underground water tables a property owner can claim.

With the emergence of new technologies of weather and climate modification, new legal doctrines are needed. What of those "rivers in the sky," the moisture-bearing winds on which nations like Honduras depend for their water? No international law protects nations that must share one river, but almost all have mutual agreements to define their water rights. One such agreement between the United States and Mexico, for example, provides for both the amount and the saltiness of Colorado River water the U.S. lets flow into Mexico. As yet no similar agreements exist between any two nations sharing a wind route. Thus nations assume the right to do as they wish with the skies over their own territory, including cloud seeding to squeeze moisture from passing clouds and, by extension, the creation of storms to prompt such precipitation—even though the storms may drift across international boundaries.

Question 2. "What constitutes natural weather and climate?" Honduras has suffered several severe droughts since the global cooling began three decades ago. Perhaps the cooling is the cause. Honduras lies on precisely the same wind and latitude belts as the Sahel region south of the Sahara Desert in Africa, which has been hit by droughts, because, say experts, the cooling has forced world monsoon rain zones toward the equator. As the map in Chapter Three shows, this Intertropical Convergence Zone used to lie against Honduras' west coast, but it shifted far to the south as the cooling deepened. Is this, and not U.S. weather modification, the reason for less rain in Honduras? This is possible, but with present scientific understanding of weather it is unprovable. It raises serious doubt, however, about U.S. guilt.

Weather and climate have changed drastically over millions of years without human intervention, and human ability to influence great natural forces is so small that we must assume that nature shapes almost all such changes today. Nature gives no nation a guarantee of permanent good weather or climate. But, to take a step back from Honduras' immediate cases, have certain industrial nations inadvertently caused the global cooling by their pollutions, or deliberately set it in motion with environmental tampering intended to improve their own

weather or climate? No law as yet holds them responsible for such things, and science cannot yet establish clearly how human activities influence climate. But more than sixty nations have carried out weather-modification experiments thus far, and the United States is by no means the only country charged with robbing rain from its neighbors. Rhodesia and Israel have both been accused of rain rustling by bordering nations.

We are beginning to think of weather and climate as unnatural, as forces subject to human control—and hence as subject to human laws.

Question 3. What are a nation's weather rights? If Honduras got 100 inches of rain in 1945, was it entitled to 100 inches of rain in 1975? By old concepts of law the question is absurd. If the river by your farm dried up from drought, or if lightning hit your barn, these were "acts of God," and were excluded from consideration by both public servants and private insurance policies.

But today that is changing. The drought might be caused by another nation's cloud seeding, and the lightning storm might have started in a foreign weather-modification experiment. As international lawyer Edith Brown Weiss of Columbia University and the Brookings Institution told the American Meteorological Society in 1972, international law will soon be forced to evolve doctrines of "weather rights."

This will require a sophisticated rethinking of what "natural weather" means. Is good weather a limited resource is a worldwide balance of good and bad weather? If so, then if Rhodesia uses cloud seeding to get more rainfall for itself, somebody else must pay by suffering less rainfall. If so, justice may require some way of redistributing this resource, which for most nations makes the difference between feast and famine.

On the other hand, the potential for good weather may be infinite and merely in need of development and exploitation. As German climatologist Hermann Flöhn points out, the skies above the Sahara Desert contain as much water vapor as those over Europe's best farmland, but the water does not fall over the Sahara. If these African skies could be squeezed, perhaps the deserts would bloom from the rainfall, but without hurting rain elsewhere. If so, then perhaps all nations are entitled to conduct weather modification, and poor nations should receive weather-modifying free aid as they now do food aid. No nation should be forced to suffer drought if a bit of environmental tampering can prevent it. And morally no nation should suffer drought if the slightest possibility exists that weather modification elsewhere has deprived them of rain that would have fallen naturally but was removed from clouds headed their way.

The United Nations may eventually develop a system of world weather welfare, using technology to correct deficient weather and climate as needed and enhancing them where desired. The alternative is a world of increasing drought, as the cooling continues, in which injured nations will rightly or wrongly blame all their weather woes on countries with big weather-modification programs, like the U.S. and U.S.S.R., or on neighboring countries that try rainmaking methods. Even if untrue, politicians may find it expedient to accuse other nations of weather modification if the alternative is to accept blame themselves for failed policies. This would increase suspicion and hostility among nations and nurture the seeds of conflict that already exist.

Weather modification conducted even-handedly by an international organization like the United Nations would arouse less hostility than would national programs, which often come with political strings attached to even the most humane offers.

The same applies to negative weather; destructive storms. If a United Nations operation, rather than Project Stormfury, had been in charge of all hurricane-modification activities on the planet, the accusation that the United States steered FiFi into Honduras would have been groundless. If we suppose the worst—that the U.S. did somehow deflect this storm—we must still assume it was an act of self-defense rather than war. America's problem was that she could redirect the storm when over her own territory or international territory (the zone of operations for Stormfury was carefully mapped in the Atlantic Ocean), but she could not fly cloud-seeding flights over the airspace of Cuba or other Caribbean nations. A U.N. force could gain permission to fly missions anywhere and use weather modification to defend all nations equally from storms, as best it could. This would entail risks, and in the foreseeable future might at best mean directing a dangerous hurricane away from population centers but into small villages and islands. Responsibility for the destruction this would cause could be shared by the community of nations.

Likewise all attempts to modify Earth's climate should be done under international control, with international responsibility. Two climatologists at the National Center for Atmospheric Research, William W. Kellogg and Stephen H. Schneider, propose "No fault climate disaster insurance," the principle that when a majority of nations approve attempts to change the world's climate they accept responsibility to compensate any nation whose climate deteriorates following the attempted modification, whether or not blame for the change can be proven. It is sufficient that the nation to be helped has suffered unusual climate and weather conditions. Such compensation could come in the form of money. More likely food aid would be provided as "famine insurance."

Given the present political problems of the United Nations, the day of global weather welfare or storm protection conducted by an international agency is many decades away. It will come when the nations now leading in weather-modification techniques realize that such programs are in their own best interest. The day may soon come when global weather forecasts are incessantly upset by national weather-modification practices, when droughts increase the likelihood of war throughout the world and the amount of hostility directed at the super-power nations, and when the threat of climatic disruption are all recognized as problems we share alike. In the meanwhile, some nations are finding good harvests at home and poor harvests abroad both in their national self-interest.

Question 4. "Can international law be enforced? Not likely at present or in the near future, for the problems are many. The nations now engaged in weather modification are serving their own self-interest. They will not relinquish the right to carry out such "peaceful" activities. Thus, U.S. undertakings like Stormfury will remain legal. Imagine a case brought before an international court, Honduras asking damages from the U.S. for Hurricane FiFi. Can Honduras prove U.S. planes seeded or otherwise tried to modify the storm? This could be difficult; judges may be forced to take the United States' word for what it did or did not do. If the storm was seeded, did this influence it or not? No scientist today could answer with absolute assurance; hurricanes do crazy things naturally, and weather-modification technology is yet primitive. What if more than one nation seeded the storm, say the U.S. and Cuba? Must weather-modifying nations accept full responsibility for a natural storm, or partial responsibility—and if the later now much? The storm might have hit Honduras without seeding. A case could even be made that the storm was Honduras' fault: her drought heated the land, which caused an updraft, which drew the hurricane toward her. The argument seems strange, but weather scientists might deem plausible. The issue before the court would be which expert to believe, for among themselves the experts disagree widely. Some say seeding has never influenced a hurricane in the slightest.

The above points, only a few among hundreds, suggest the complexity involved in enforcing weather-modification laws. Laws governing climate modification, an infant science, would face ten times the difficulties inherent in weather modification.

Because clouds, winds, and storms ignore national boundaries, we have considered the international legal problems of countries tampering with climate and weather. But law is evolving within countries too, and is establishing principles that someday may extend to international law. A case now in American courts may set a major precedent for all future regulation of the now-lawless skies.

On June 9, 1972, a small cloud-seeding airplane took off from the airport at Rapid City, South Dakota. A few miles west of the city its pilot dumped 650 pounds of salt, sometimes used to act as condensation nuclei for atmospheric water, into a bank of clouds. The plane was flown as part of the U.S. Department of the Interior's "Project Skywater," an operation to increase rainfall.

A rainstorm followed, and with it one of the worst floods in American history. There were 238 people killed, and hundreds of millions of dollars' worth of property was destroyed. Rapid City, a town of nearly 50,000 people, was almost washed away. State and federal governments provided \$64 million in relief to help rebuild the city.

But this was not an "act of God," said some townspeople. It was caused by government cloud seeding. In 1974 flood victims asked the Interior Department to accept responsibility for their damages. The agency refused. On June 3, 1975, relatives of four people killed in the Rapid City flood brought suit against the Interior Department, seeking \$1.7 million for loss of life and property damage. Twelve hundred of the flood's victims are considering a class-action suit, reportedly to ask \$600 million in damages from the government. In both cases attorneys will contend that the flood was not wholly "natural."

In the whole history of weather modification only fourteen suits had been brought before this, says Howard Taubenfeld, a law professor at Southern Methodist University and America's foremost expert on weather law. Moreover, no damages have ever been assessed. Most dealt with weather modification under other laws: water rights, invasion of privacy, trespassing, destruction of property.

The Rapid City suit charges that the U.S. government was negligent and irresponsible in its cloud seeding, and it may have a case. David Hacker of the National Observer reports that evidence may show the cloud-seeding pilot on that June day was told to seed clouds south of Rapid City because officials feared a flood if clouds were seeded west of the town.

Even if the pilot seeded clouds contrary to the warning of his superiors, this does not prove his seeding caused any rain, or that the rain it might have produced was the flood's cause. However, a NOAA study said the Rapid City flood "averaged about four times the six-hour amounts that are expected once every 100 years in that area." And Project Skywater operates on the assumption that seeding works and can increase rainfall by 10 percent or more. Flood victims may decide that the cloud seeding was responsible for 10 percent of the damage they suffered. The suit will be a battle of experts, and is expected to be in the courts for years. Many specialists concur with the head of South Dakota's weather modification program, Martin Schock, who says "the cloud seeding did not materially contribute to the flood," but concedes that it might have increased rainfall somewhat. Did weather modification increase rainfall enough to warrant granting the victims damages? Most states, including South Dakota, license or otherwise restrict cloud seeders, and in this case the pilot was flying for a government project. If the court finds in favor of the flood victims, a new era of weather- and climate-modification law will have begun. In the meanwhile the Federal Government has started requiring environmental impact statements from all cloud-seeding operations.

Lawsuits and bureaucratic rules provide some restraint on weather and climate modification. Another form of regulation is direct democracy, as Colorado citizens showed in 1972. In Colorado's San Luis Valley, the people raise cattle and grow potatoes and, for the Coors Beer Company, Moravian barley. Coors invested heavily in cloud seeding over the valley—to provide the right amounts of rain while the barley grew, to prevent rain during harvest time, and to suppress hail that could harm crops. Farmers not growing barley in the valley objected that such weather modification robbed them of rain needed for their crops. Protests arose. A cloud-seeding airplane was shot at, and a dynamite bomb was used against a radar station that assisted in the seeding. The farmers conducted a straw ballot along with the regular November elections in 1972 and voted three to one to stop the cloud seeding. Coors threatened to cut off all barley buying from the valley if its cloud-seeding operations were stopped, but following hearings before the state Department of Natural Resources the corporate weather modification was ended. Such weather modification could become a proper ballot issue wherever it threatens to shape the weather for all in order to benefit a few.

If such a ballot had been conducted in South Dakota, suggest Drs. Kellogg and Schneider of NCAR, then "a statewide premium could have been levied and a no-fault weather modification insurance policy could have been issued to every citizen who could be affected by the operation." This would have provided some protection for the Rapid City victims. It also would have provided a restraint on the weather modifiers, government or non-government, for the price of such insurance premiums would be determined in part by the strictness of legal, ethical, and scientific controls over their operations.

None of these legal regulations over weather modification can provide complete answers to the issues raised, but they suggest some preliminary steps lawmakers need to consider.

WEATHER, CLIMATE, AND WAR

Deliberate destruction of an enemy's natural environment is nothing new in the history of warfare. When, after three bloody wars, the young Roman Empire conquered Carthage in 146 B.C., the victors sowed salt into Carthaginian fields to destroy their fertility for future generations. In America's Civil War, Union General William T. Sherman marched an army across Georgia and had his soldiers kill every animal, trample every crop, burn every building along their path. "War is hell," he said, and proved it by leaving a sixty-mile-wide zone of devastation in his wake. During the Nuremberg war crimes trial following World

War II one Nazi general was convicted of, among other things, the crime of deliberately flooding parts of the Netherlands to punish political dissenters. The list could go on and on, because for thousands of years armies have scorched earth and laid waste to land in trying to achieve victory or revenge.

Such warfare methods in the past had two things in common. They were aimed at the natural ecological base from which an enemy survived and thrived—his farmlands, streams and rivers, forests, and livestock. And they were, almost without exception, tactics rather than strategy. They were used ad hoc, often on the spur of the moment, to achieve quick victory, to shock, to break an enemy's will. They were weapons used in the heat of passion, rather than in cool calculation.

But when, in 1973 Secretary-General Maurice Strong of the United Nations Conference on the Human Environment predicted "that in 10 or 15 years environmental aggression will be a major source of political conflict," the art of war had already changed. A new form of war based on the cold, systematic destruction of an opponent's natural environment had been used in a small nation called Vietnam, and it appeared to be the prototype for all future combat—a frightening form of total war that asks no quarter and offers no mercy, that lays waste to the land with all the sophistication that biological and weather science can provide.

Even today, few Americans understand what their policymakers were trying to do in the Indochina War. The war was fought not only to "prevent a communist takeover" in Southeast Asia, but also to provide the Department of Defense with a laboratory in which it could experiment with new methods of warfare. During the 1950s under President Dwight Eisenhower, America's military policy was simple: Marxist aggression anywhere would be met with "massive retaliation" by U.S. nuclear weapons. By 1960 this doctrine had proved unworkable. How can an atomic sledge hammer reasonably be used against guerrilla movements and the brushfire wars they were stirring up in nations throughout the world? When President John F. Kennedy entered the White House in 1961 he and Defense Secretary Robert McNamara set about creating a more viable military posture for the United States.

Kennedy's new doctrine was called "flexible response," and was dedicated to "defeating the enemy at his own level of aggression." If an enemy was a rag-tag army in the jungles of Indochina, he could be beaten by a small commitment of troops to the jungle. Kennedy ordered 14,000 armed U.S. troops into combat in the long-lived Vietnamese civil war to test "flexible response." Gradually the U.S. military commitment increased, and in 1965, when the new policy seemed to be failing, President Lyndon B. Johnson escalated the conflict with a massive infusion of men, equipment, and new ways of fighting.

In the defense community in Washington, D.C., "flexible response" was thought of as humane. It was, after all, an alternative to the potential horror of nuclear war that had loomed ominously over the Eisenhower years. But as each new military escalation in Vietnam seemed to bring U.S. policy no closer to victory, almost every weapon in the arsenal of democracy was used short of atomic weapons.

America was unprepared for a guerrilla war, just as the British two centuries before had been unprepared for it in their American colonies. Guerrillas attack and then disappear—into the jungles, and into villages where they look like innocent peasants. American military analysts said from the first that an anti-guerrilla war in Vietnam could not be won unless the United States and her allies could put fifteen troops into the field for every guerrilla. Throughout the long conflict U.S., South Vietnamese, and other allied troops never outnumbered the enemy's fighters by more than four to one.

But, said some analysts, victory might come by other means. If the enemy hides in villages, then remove the villages. Vietnamese peasants by the millions were moved to protected compounds, likened by some critics to concentration camps. Those outside these huge strategic hamlets were then regarded as the enemy and often shot on sight.

And if the enemy hid in jungles, the solution was simple: remove the jungles. This tactic never would have been thought of, much less considered, by military planners of the past—in part because earlier technologies were unable to speedily remove whole jungles, and part because such an idea would have seemed insane. But in 1965 the United States began clearing vast areas of Vietnam, using methods both mechanical and chemical.

Giant bulldozers were set to work uprooting whole tropical forests that had been designated enemy strongholds. The machines were called "Rome Plows," perhaps in honor of Carthage, and the typical type was a 20-ton caterpillar tractor fitted with an 11-foot-wide plow blade. Each tractor carried 14 tons of armor plate. Each plow blade weighed 2½ tons. To attack a forest, typically, thirty such tractors would gang together and move forward in a phalanx, smashing down huge trees and leaving the ground scraped clean where they had passed.

By 1971 the plows had cleared at least three-quarters of a million acres in South Vietnam, and were adding a thousand acres daily to the total.

The land was also cleared by bombing and shelling. In a 1972 Scientific American article, Drs. Arthur Westing and E. W. Pfeiffer estimated that between 1965 and 1971 U.S. forces had exploded 26 billion pounds of munitions in Indochina, energy equivalent to 450 Hiroshima nuclear bombs. In the whole of Indochina this averaged to 142 pounds of explosive for each acre of land, 584 pounds for each person. In South Vietnam an overall average of 497 pounds of explosive per acre were used, 1,215 pounds per person. This hurt the land as well as the people. The soil was pockmarked with an estimated 26 million craters. At least 10 percent of the agricultural land of South Vietnam had been abandoned because of this damage.

Up to half the land in Indochina is lateritic. Exposed to open air, it hardens to brick, and as Yale University biologist Dr. Arthur W. Galston writes, "this brick is irreversibly hardened; it can't be made back into soil. . . ." Thus a hole in the ground cannot simply be filled, nor can the land be brought back to fertility easily. "It is doubtful," said Westing and Pfeiffer, "that many of the forests and lands of Indochina can be rehabilitated in the foreseeable future."

Another 5 million acres of Indochina forest and cropland were bombed with chemical defoliants and herbicides designed to kill plants or make trees drop their leaves. This, too, was done "to deny the enemy cover" beneath jungle canopy, and to a lesser degree to deny the enemy food by killing his crops. The problem with this latter policy, as Harvard University nutritionist Dr. Jean Mayer warned, is that in a war soldiers get first food priority. However severe the malnutrition in Southeast Asia, the enemy fighters would eat while peasants—especially the old, the young, and the sick—starved. Food destruction was tantamount to war on civilians.

The problem with mass defoliation is the ecological damage it can do far outweighs its military gains. It cannot be done piecemeal, for an enemy can easily move half a mile to intact trees if leaves began to fall over his base of operations. But mass spraying of defoliant chemicals over wide areas risks destruction of the whole natural web of life in a region, now and for decades or centuries to come. Science cannot certify any large-scale defoliation effort as safe, because as yet our understanding of how living things depend on one another—how trees nurture insects that feed birds that fertilize trees, as one crude example—is too sketchy to enable us to predict what will happen in a forest if we strip the trees naked. In the tropics of Southeast Asia, where soil is thin, and where it has been protected by evergreen trees for millions of years, we must assume defoliation can devastate all traditional life cycles.

Despite these risks and potential problems, the United States carried out a program of mass defoliant and herbicide spraying in Indochina. How much was used is unknown. The highest unofficial estimate for the whole area is 6 million tons. Officially, the U.S. military acknowledged spraying or dumping 50,000 tons of such chemicals in war zones within South Vietnam as of 1970, of which, writes investigative reporter Thomas Whiteside, "20,000 tons have apparently been straight 2, 4, 5-T."

This designation 2, 4, 5-T is shorthand for a type of trichlorophenoxyacetic acid, an active ingredient in America's most popular Vietnam herbicide, "Agent Orange." After many thousands of tons of it had been dropped over Indochina forests, where rain would wash it into the drinking water of farmers and peasants, research in the United States revealed that when fed to pregnant rats 2, 4, 5-T causes terrible mutations and birth defects in every litter born. Such mutations reportedly have increased among humans in Indochina during the past decade, and have appeared in Globe, Arizona, where 2, 4, 5-T was used as a weed-killer near canals carrying water used locally. The chemical does a good job of killing unwanted plants, and presumably of making trees drop their leaves. It also provides what poet Bob Dylan called the "worst fear" that can be hurled at an enemy, "fear to bring children into the world."

The damage from defoliants spreads out in widening circles. For example, wrote Dr. Galston, 2, 4, 5-T devastated up to 40,000 hectares of mangrove trees, many around the Saigon River. "Ecologists have known for a long time that the mangroves lining estuaries furnish one of the most important ecological niches for completion of the life cycle of certain shellfish and migratory fish. . . . In the years ahead the Vietnamese, who do not have overabundant sources of protein anyhow, are probably going to suffer dietarily because of the deprivation . . . of fish and shellfish." Trees die. Denuded land erodes, dries to brick. The animal and insect life of the forest perishes. Often predators succumb before their prey, which then proliferates. (For example, in the Sahel region of Africa some rains returned in 1974 and 1975, after six years of severe drought. As of January 1976 the nations of Senegal, Mali, and Mauritania in the Sahel were being devastated by a rat plague; in some regions, estimated experts, one rat was alive and eating crops for every square meter of land.) With natural stability and equilibrium destroyed in Indochina, harmful insects and other pests have been on the increase, as have several contagious diseases.

All these changes help influence weather and climate in Indochina. The winds blow differently over bare grasslands than over forests. Stripped, the land is more desertlike. Less rain should fall, but the annual monsoons should bring increasing erosion and flooding. The region should be slightly less humid, but hotter. Crops will be harder to grow. Storms should do more damage than before, and over a wider area for each storm. Vietnam lies in the same belt of latitude as the African Sahel. If the global cooling progresses, it may increasingly suffer from flood and drought, made all the worse by the after-effects of America's experiment with eco-war.

But U.S. environmental tampering was not limited to the land. American bombers modified the rainfall over Indochina, too. Chemicals were dropped into clouds over North Vietnam, and perhaps elsewhere, to give acidity to the rain. This "hydrosopic" seeding, said Pentagon officials, was to foul up radar antennas that directed enemy anti-aircraft missiles. Whether the acid rains also injured living things is unknown, but is a possibility. The question merits study. In some parts of the eastern United States the acidity of rainfall has increased to 1,000 times what it was in 1955, apparently a result of industrial and other pollution.

And the U.S. caused rain. A 1974 congressional investigation found that between 1967 and 1972 the Department of Defense spent \$3.6 million each year seeding rainclouds over North Vietnam, South Vietnam, Cambodia, and Laos. During 1967 and 1968, the only years the Pentagon said it seeded clouds over North Vietnam 1,115 seeding units were dropped there.

The declared goal of the seedings, which in at least one instance increased rainfall over enemy territory by 30 percent, was to muddy vital trails and hamper movement of men and supplies. Pentagon officials said it succeeded, and defended the program as an inexpensive and humane weapon of war. "Raindrops don't kill people, bombs do," said one spokesman. CIA experts privately called the seeding operations a failure.

In 1971, while American aircraft continued cloud seeding over other Southeast Asian countries. North Vietnam suffered the heaviest rainfall since 1945. Floods resulted, and inevitably killed many. The 1945 floods killed more than a million people, most by starvation. The 1971 floods ruined North Vietnam's rice crop and must have caused serious hardship, if not famine. The Department of Defense denied responsibility for the unusual rainfall when questioned about it years later. But before the floods the Pentagon had instituted a policy of bombing dikes used for flood control in North Vietnam.

The military rainmaking was kept highly secret, not coming to public attention until Dr. Daniel Ellsberg released the so-called Pentagon Papers in 1970. The papers, a classified history of Defense Department policymaking in Vietnam, referred in Volume Four to weather-modification experiments "successfully" conducted in Laos in 1966, and to a weather-modification program named Operation POP EYE designed to "reduce trafficability along infiltration routes" used by the enemy. Earlier in the volume a list of escalation proposals given to the president by the Joint Chiefs of Staff in 1967 included: "8. Cause interdicting rains in or near Laos."

Syndicated columnist Jack Anderson, in his Washington Post column of March 18, 1971, said that U.S. Air Force airplanes had been seeding clouds over the Ho Chi Minh trail, which runs through both Laos and Cambodia, since 1967 under a project code-named "Intermediary-Compatriot."

Pentagon officials said they knew of no ongoing operations by those names, and they spoke the truth. In 1974 testimony before Rhode Island Senator Claiborne Pell's Subcommittee on Oceans and International Environment, Deputy Assistant Secretary of Defense Dennis J. Doolin explained why: Operation POP EYE and Intermediary-Compatriot were the same. Whenever the code names for military rainmaking operations "were uncovered they were changed," said Doolin.

Pell conducted extensive hearings into military weather and climate modification during 1972 and 1974. A subcommittee chaired by Minnesota Congressman Donald Fraser did the same in the House of Representatives in 1974 and 1975. What emerged was an awesome picture of far-ranging research and experimentation by the Department of Defense into ways environmental tampering could be used as a weapon.

Perhaps the most amazing aspect of the hearings was that they surprised lawmakers. Military people have always been fascinated with weather, especially weather on the days of important battles. This is logical and proper, for weather conditions can determine an army's capabilities, just as a muddy or dry track can decide the winner of a horse race. And the Defense Department had been deeply involved with U.S. weather modifications from its earliest days, flying the airplanes of Project Cirrus and later co-sponsoring Project Stormfury's study of hurricane manipulation. Many states' laws have held that adultery could be proven by as few as two things: motive and opportunity. Military planners had the motive to find weapons potential in any new technology, and they had the opportunity from the first to work with weather modification.

But lawmakers were unaware of how far Defense Department study had gone into military uses of environmental tampering. As expected, the Pentagon had more than half a dozen programs researching control of warm fog, cold fog, cloud dispersal, and, jointly with the Soviets, hail suppression. Less known, the Pentagon had entered the rainmaking business, using its cloud-seeding aircraft to end droughts in the Philippines and the Azores. This had been done, officials said, because both places had important U.S. military bases and rainfall could improve the lives and political well-being of American military personnel. As the hearings brought out, several nations suffering drought and mass starvation in the African Sahel appealed for cloud-seeding help to the U.S. government shortly after the military seeding of the Azores a thousand miles away. (In 1967 the U.S. Navy tried, with little success, to provide cloud-seeding aid to drought-stricken India.) The Sahelian appeals were refused; they were told that private American cloud-seeders could be hired to do the job.

In 1966, Gordon J. F. MacDonald, then a member of the President's Science Advisory Committee and later of the President's Council on Environmental Quality, published a series of ideas for the military use of environmental tampering. "The key to geophysical warfare," he wrote, "is the identification of the environmental instabilities to which the addition of a small amount of energy would release vastly greater amounts of energy." For example, he said, "a controlled hurricane could be used as a weapon to terrorize opponents over substantial parts of the populated world."

MacDonald saw limited military application for rainmaking as a weapon directly, but a good use for it indirectly in stealing an enemy's rain: ". . . a competitor country could be subjected to years of drought. The operation could be concealed by the statistical irregularity of the atmosphere." MacDonald also analyzed how an enemy nation could be destroyed if holes were punched in the atmospheric ozone layer above it, exposing its people to dangerous levels of ultraviolet radiation from the sun. This might be done, he said, by increasing the amount of ultraviolet radiation striking that layer at the specific wavelength of 250 millimicrons. As I published in my syndicated column in 1972, the Defense Department was rushing development of a new type of laser cannon that could produce this precise ultraviolet wavelength; such a cannon, mounted in a stationary-orbit satellite and powered by sunlight, could scan downward and chop a continuous hole in the ozone layer above an enemy target, such as the Port of Haiphong in North Vietnam. This is one of several Pentagon projects aimed at the development of lasers that can direct super-intense beams of light on a specific wavelength resonant with molecules in a target; if perfected, such lasers could do more than melt a target—they could shatter its structure, as sound-waves at the right pitch can shatter a drinking glass.

Earthquakes would make good weapons, wrote MacDonald, and so would the tidal waves that undersea earthquakes can produce. If atmospheric electricity

can be controlled, lightning storms can be directed against an enemy. And perhaps resonant electrical pulses in the atmosphere could be controlled to damage the delicate biological rhythms or brainwave patterns of people in another country.

The Department of Defense has taken action in all the areas MacDonalld described. It has used rainmaking in the Indochina conflict, and studied ways to damage the ozone layer both with lasers and chemical-reagent bombardment. It has studied ways to detect and cause earthquakes through "PRIME ARGUS," a project of the Pentagon's Defense Advanced Research Projects Agency (DARPA). It has studied lightning through the resources of Project Skyfire and hurricane manipulation through its role in Project Stormfury.

And under "Project Sanguine" the Pentagon has studied potential effects on humans of electrical impulses in the atmosphere. In a May 1972 radio broadcast in San Francisco I discussed in detail why the U.S. Navy could not reliably reach its own submarines in a national emergency. Its prime communication with the submarines, I said, depended on only three main transmission sites in the world, and these could readily be sabotaged. The following day Navy communications chief Rear Admiral Samuel Gravely hurriedly called a press conference in San Diego to announce his discovery that the Navy communications system was "at least fifteen years out of date," and that the president might be unable to reach his submarines with codes needed to unlock their missile nuclear warheads in an emergency.

To remedy this, said the Navy, was Project Sanguine, a plan to bury up to 25,000 square miles of antenna somewhere in the United States. This antenna would be used to transmit many millions of watts energy on very, very low radio frequencies that can penetrate water. What effect would such powerful transmissions have on humans near the antenna? The Navy has tried to build Sanguine in Wisconsin or Texas or Michigan, and in each state has been opposed by environmentalists citing the project's unknown dangers. Nonmilitary research indicates that some kinds of radio transmission can kill bacteria and other living things. Work by Dr. Ross Adey at the University of California, Los Angeles, indicates that the "biological clocks" of living things can be disrupted by transmissions on frequencies not far different from what Project Sanguine would use. Sanguine critic Senator Gaylord Nelson forced the Navy in 1975 to release its research showing that Sanguine-like transmissions can alter human blood chemistry.

As early as 1958 the chief White House advisor on weather modification, Captain Howard T. Orville, declared that the Defense Department was studying "ways to manipulate the charges of earth and sky and so affect the weather" by means of "an electronic beam to ionize or de-ionize the atmosphere over a given area." Perhaps then-Senator Lyndon B. Johnson had this in mind when, in 1957, he told the assembled House and Senate: "From space one could control the Earth's weather, cause drought and floods, change tides and raise the level of the seas, make temperate climates frigid." (Captain Orville also discussed ongoing U.S. Air Force experiments with "sodium vapor, ejected from jet planes, to intercept solar radiation" over enemy countries and ruin their weather.) But as Stanford University scientist Robert Helliwell revealed in 1975, we are already inadvertently altering the ionosphere above our heads with the Very Low Frequency radio energy emitted by all electrical power lines, whose VLF output is on wavelengths much like those planned for Project Sanguine and already used by military broadcasting facilities in Antarctica and elsewhere. While working in Antarctica Helliwell discovered that these VLF signals can be multiplied up to 1000 times by a coherent interaction with particles in our planet's radiation belts above the Earth; the radio signals cause an "electron rain" in the ionosphere, and this inevitably alters weather patterns in the lower atmosphere. The Defense Department is already studying this phenomenon.

MacDonalld proposed one other environmental weapon: climate modification. A "landlocked equatorial country," he wrote, might see advantages in raising world sea levels by melting the polar caps, or in using technology to hasten global cooling and the dawn of an Ice Age. He assumed, wrongly, than an Ice Age would improve climate in tropical regions: it would more likely cause drought.

The Department of Defense has been fascinated by climate modification since the early 1950s, when U.S. military intelligence learned of a Soviet plan to ruin climate in the United States. The plan was to build a jetty 50 miles or more long out from near the eastern tip of Siberia. The jetty would contain several atomic-powered pumping stations that would push cold Arctic waters down through the Bering Strait between Siberia and Alaska. This would cool the

Bering Sea and inject increasing amounts of icy water into the ocean current that flows down along the west coast of Canada and the United States. The result would be colder, more stormy weather throughout North America and enormous losses to the American economy in agriculture, work days, and storm damage. Military experts knew about the beginning of the global cooling trend, and they had to wonder whether the Soviets were to blame for it. In retrospect, this seems illogical: the Soviet Union has been hurt worse by the cooling than most other nations, and by its plan hoped to set up a new ocean current drawing warm Gulf Stream waters into the Arctic. But Pentagon planners worried and started studies of ways to change climate.

Defense Department climate research coalesced in the early 1970s in a DARPA project called "Nile Blue." In fiscal 1972 the project had a budget of \$2.587 million to develop and monitor computer "models" of changes in world climate. For this purpose it was provided the most sophisticated computer yet developed, the "ganged" ILLIAC IV system, which alone could handle the mass of data and subtle changes that make weather prediction so difficult.

But about that time political controversy was growing in the wake of revelations about Pentagon rainmaking in Vietnam. Should the military be working with weather and climate modification at all? asked critics and a few lawmakers. Its budget threatened, Nile Blue changed its name to "Climate Dynamics" and DARPA, under whose control it remained, announced that henceforth the program was completely open and un sinister. In 1973, in a seemingly unrelated event, Dr. W. Lawrence Gates announced that the Ames Research Center in California had just acquired a new ILLIAC IV "ganged" computer from DARPA, which he would be using for world climate modeling. Dr. Gates is head of climate research at the RAND Corporation in Santa Monica, California. The RAND Corporation was established in 1948, at the beginning of the "Cold War" between the United States and Soviet Union, to serve as a civilian intelligence arm of the Department of Defense. Now diversified, it still does classified military studies for the Pentagon. As a private organization, the RAND Corporation is not subject to the same degree of congressional scrutiny as the Department of Defense.

In 1972 congressional hearings before Senator Pell's subcommittee, the Defense Department said it was conducting no classified weather research. Climate research was unmentioned. It defended Nile Blue as giving military planners a needed "capability to predict the climate 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."

"The Soviet Union," said the Defense Department in response to questioning by New Jersey Senator Clifford Case, "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 Strait, and diversion of Siberian rivers.

"These programs," the Defense Department statement continued, "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 climate changes are clearly potentially grave threats to national security, and have consequent implications for military planning."

The Pentagon's position was that Nile Blue had too much military significance to be transferred to civilian control. It has never explained how, under military control, the program can serve as a "scientifically credible" instrument able to sway "world opinion."

Could such a computer climate-modeling program as Nile Blue have aggressive military potential? Certainly. Its findings can provide military planners with knowledge of those key "environmental instabilities" Dr. MacDonald said were essential to the successful use of environmental warfare. As Robert M. White, Administrator of the National Oceanic and Atmospheric Administration, has said, "It is not possible to draw clear distinctions between research and technological development on weather modification for hostile and nonhostile pur-

poses." "Obviously," said Maryland Congressman Gilbert Gude, "such knowledge can be used for offensive military purposes."

In 1975 Senator Pell and Representatives Gude and Fraser, the three leading legislative critics of American military research into weather and climate modification, sent a letter to President Gerald Ford urging increased government support for peaceful uses of such modification. They also urged that all such research and operations, military and non-military, be placed under the control of an oversight civilian agency answerable to the president and to Congress.

Officials admit that Pentagon climate modeling has studied ways and means and probable results of melting the polar ice caps, and the possible consequences of Soviet schemes to melt the Arctic ice pack. They have also studied how to make and direct tornados and hurricanes, and how to destabilize weather in the Soviet Union, China, and Cuba, which would ruin their harvests and thereby strengthen the U.S. "food weapon."

Such research is controversial because it seems contrary to American ethics of warfare. Environmental warfare, especially involving weather and climate modification, can be used against an enemy secretly, as the U.S. did over Indochina for several years with its rainmaking operations. One limitation of its use is imprecision: a storm will hit civilians as well as enemy soldiers, and it may cause unforeseen secondary effects that will harm whole populations. American declared policy has long been to avoid waging wars on whole peoples, to renounce weapons that injure innocent citizens. This was one reason President Richard Nixon ordered destruction of all American germ weapons, for their use, like that of weather or climate modification, could not be limited to precise targets. The United States has never explicitly renounced environmental modification as a tool of policy.

During a summit meeting between President Nixon and Soviet Premier Leonid Brezhnev on July 3, 1974, the nations agreed to conduct discussions toward a ban on environmental warfare. Before the first of these discussions, set for Moscow in November, got under way, the Soviet Union introduced a resolution before the United Nations General Assembly to ban environmental warfare. When revised, the resolution was passed by the body 102 votes to none. The United States and half a dozen other nations abstained from the vote. Senator Pell suspected that the president felt miffed by the surprise Soviet action, a move that made it appear that the Soviet Union and not the United States had taken the lead in trying to ban environmental modification. In fact, the Soviet resolution was similar to one passed by the North Atlantic Assembly in November 1972 and to another authored by Senator Pell and passed by an 82 to 10 vote by the United States Senate in July 1973.

All these resolutions present us with problems and ironies. Because weather and climate war can be secret, how shall we detect them without international inspection of some sort? The Soviets have always balked at such inspection. What constitutes military versus peaceful use of environmental modification technologies? Is the difference one of effect or intent? The Soviet resolution before the United Nations, for example, forbade "modification of the natural state of the rivers, lakes, swamps and other aqueous elements of the land" if this produced "harmful consequences." But the Soviets are already in the process of reversing the flow of Pechora River, whose waters naturally flow into the Arctic Ocean. Reversing such rivers, experts warn, may warm the Arctic by reducing its total fresh-water input, and hence diminish the ice pack. The Soviets have also dammed several rivers to create inland seas. Such actions will have a climatic impact far beyond the borders of the U.S.S.R.

Two weeks after the first U.S.-Soviet discussions on banning environmental warfare, President Ford and Soviet leaders met in Vladivostok, Siberia. One of the items secretly discussed during this summit meeting was the state of joint Soviet-American research in the Arctic and the Bering Sea. This research had been undertaken to evaluate the cooling trend in Earth's climate, consider what threats it posed to both nations, and discuss whether weather and climate modification technologies should be tried in dealing with it. One idea long considered by the Soviets is damming the Bering Strait between Siberia and Alaska. This possibility was mentioned at the Vladivostok meeting. Information gathered from the joint U.S.-Soviet research effort in this region would be used, it was agreed, in analyzing any such plan.

Any such attempt at global climate modification could be seen as a hostile act by a nation whose weather worsens—and because the global cooling trend has already made weather less stable everywhere, many critics will call for the prohibition of all major climate-modification programs.

Discussions between U.S. and Soviet negotiators resumed in Washington, D.C., on February 24, 1975. On August 21, 1975, the two nations presented their jointly produced draft treaty banning environmental modification as a weapon of war to the thirty-one-nation Geneva Disarmament Conference. It prohibits signatory states from engaging in "military or other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to another party state." Would such a provision ban Soviet river modification? Perhaps not, for it is neither military nor hostile. Would it forbid U.S. cloud seeding in Vietnam? Perhaps not, for the effects of such seeding admitted to by the United States were neither widespread, long-lasting, nor severe; as one military analyst said in defense of the seeding, "People in Southeast Asia are used to heavy rains."

Climate modification would most likely be used as a form of economic warfare, to destroy crops or hamper transportation or production. In the case of Soviet river modification, such damage might come to China purely as a by-product of efforts by the Soviets to improve their own climate. And the draft treaty is explicit: nothing in it shall be taken to prohibit or limit peaceful methods of environmental modification a nation uses to help its own people. Also nothing in it provides for international inspection or monitoring, without which treaty violations would be difficult to detect or determine. Indeed, if the global cooling trend continues and world food production suffers, people will begin demanding that weather and climate modification be tried to offset damage done by natural forces. Few will want these methods of warfare banned. Many will want them to be directed against the cooling itself.

NORTH DAKOTA WEATHER MODIFICATION BOARD,
A DIVISION OF NORTH DAKOTA AERONAUTICS COMMISSION,
Bismarck, N. Dak., June 17, 1976.

Hon. GEORGE E. BROWN, Jr.,
U.S. House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN BROWN: I am pleased to have the opportunity to offer a written statement for the record concerning H.R. 10039 and S. 3383, both bills dealing with weather modification.

I encourage federal weather modification legislation which:

- a. Provides for adoption of a national policy on weather modification which utilizes state expertise and local users in the development of this policy.
- b. Provides for strong local (user) control and decision making powers in order to minimize social concerns.
- c. Provides for continuing development of state regulatory authority and interstate cooperation.
- d. Encourages a search to expand the present "state-of-art" technology consistent with user defined needs.

Discussion which supports these recommendations is provided below.

BACKGROUND IN NORTH DAKOTA

Weather modification began in the early 1950's in North Dakota. Farmers recognized that one of their problems was an unstable agricultural income caused by a highly variable climate from year to year; increasing seasonal rainfall would reduce their risk of producing a crop. In 1961, an effort began in southwestern North Dakota for treatment of hail bearing clouds to reduce the crop hail damage.

This effort by the Southwestern North Dakota Hail Suppression Association grew to four counties in the mid-sixties and continued successfully for fifteen consecutive years through the 1975 hail season. In the mid-sixties and again in 1973, additional counties began their grassroots cloud seeding projects financed through county-wide associations. This activity and interest in cloud seeding grew to a level involving 21 of North Dakota's 53 counties during the summer of 1975.

The growing grassroots concern during these years led to several legislative changes and finally adoption of a comprehensive law in 1975 providing for regulation of weather modification in North Dakota.

NORTH DAKOTA WEATHER MODIFICATION LAW

The provisions of the present North Dakota Weather Modification Law (NDCC 2-07) also provide the foundation for the control of cloud seeding in this State.

a. Local county authorities established by majority vote (petition or ballot) represent citizens' concerns and needs, monitor operations, and have decision responsibilities.

b. These authorities are organized into operations advisory committees for multi-county operations and have policy making powers upon final approval by the North Dakota Weather Modification Board.

c. The North Dakota Weather Modification Board: 1. Controls the quality of cloud seeding operations by issuing licenses and operational permits before controllers can conduct field operations; 2. Provides, through its staff, coordination with other agencies (intrastate and interstate); 3. Provides technical staff responsible for the design and monitoring of field cloud seeding operations; 4. Coordinates the local level needs of operations advisory committees; and 5. Requires controllers to keep detailed records of cloud seeding operations and to submit end-of-season reports.

1976 WEATHER MODIFICATION PROJECT

The 1975 North Dakota Legislature provided funds adequate to cost-share 50% of costs for cloud seeding services over seventeen counties during 1976. The counties are funding the remaining 50% through county-wide taxes authorized by NDCC 2-07. The principle objective is to reduce damaging hail, while seeding is conducted on smaller cumulus clouds to enhance rainfall.

Specific individual cumulus clouds are identified as treatable or untreatable using decision procedures transferred from present technical achievements. The data input includes weather data received under a cooperative agreement with the National Weather Service and one weather radar placed centrally in three operations districts of the participating counties.

A licensed meteorologist on field location at each of the radar coordinates delivery of the treatment material by aircraft. A total of fourteen aircraft are strategically located at airports throughout the participating counties. A full capability communication system provides coordination between aircraft and radar for the three district areas.

FEATURES OF THE NORTH DAKOTA PROJECT

Several features of the cloud projects in North Dakota and NDCC, Chapter 2-07 are worth listing in light of pending Federal weather modification legislation.

a. The projects are user controlled.

b. The projects are regulated and monitored by a State agency.

c. Controllers must provide detailed reports of their operational activities.

d. The projects must include safeguards to protect the public interest.

e. The projects are operating successfully across state boundaries in cooperation with local efforts in South Dakota.

f. The projects have been coordinated with the upwind State of Montana in accordance with its law and regulations.

PRESENT NEEDS OF THIS PROJECT

Decision processes to implement programs balance positive factors against negative factors. The negative factors in application of weather modification (cloud seeding) at this time are not those which provide disbenefits, but those which relate to the limited capability of the technology. While weather modification remains controversial, I believe prudent application of it through a sound decision procedure in the field, which uses safeguards, can reduce any negative aspects to an acceptable minimum level.

Thus, my definition of negative factors means those technical inadequacies which limit the application and success of the field projects. They are:

a. An additional 10% or 15% increase in seasonal rainfall during a drought (although helpful in alleviating dry conditions and improving crops and the economy) does not provide the rainfall necessary for optimum crop production.

b. A 50 percent reduction in hail damage achievable by the evidence of some projects still leaves 50 percent damage. For example, a parcel of land exposed to two hail storms still gets damaged even though the first might have been significantly affected by seeding.

c. Present equipment limits the successful treatment of clouds.

Additional research is necessary and must continue to refine the understanding of cloud processes and treatment methods to expand the technical capabilities now being applied.

The high use and cost of energy and the low margin of profit by the farmers motivates them to strive to improve their production.

While present research may be useful by assisting further development of applied projects, the research must begin considering the evaluation of large scale projects such as ours in North Dakota.

I appreciate this opportunity to provide some of my concerns on behalf of the users in North Dakota.

Sincerely yours,

MARTIN R. SCHOCK, *Director.*

NORTH CAROLINA STATE UNIVERSITY,
Raleigh, N.C., May 28, 1976.

Mr. FRANK R. HAMMILL, Jr.,
*Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.*

DEAR MR. HAMMILL: Many thanks for asking me to express my views on H.R. 10039 and S. 3383, dealing with the subject of weather modification.

H.R. 10039 is a bill ahead of its time. There is no present need for additional regulatory legislation. The weather modification reporting procedures under Public Law 92-205 are being carried out very nicely by the Department of Commerce. The Commerce reporting program also allows State officials and project personnel to be alerted if an activity poses a possible hazard to the public, property or the environment, or interference with Federal research. In my opinion H.R. 10039 would hinder—because of overregulation—rather than help the further development of weather modification research and development in the United States.

S. 3383 is a most timely bill, for we sorely need to develop a national policy on weather modification. Weather modification represents a potential tool for augmenting water supplies in areas where additional water is needed for energy, food, and fiber production. Now is the time to forge a sound national policy and develop a set of guidelines and strategies for the next decade of research, development and demonstration.

I believe that S. 3383 is seriously flawed in two important ways and approval in its present form would not result in accomplishing the desired goals. First, one year is too short a time for study, review, analysis and the thoughtful presentation of an effective national policy. Two years would be a more realistic time frame for this complex task. Second, the Department of Commerce is a sister Federal agency and I don't believe it is prudent or practical to ask Commerce to do the job. Everything I know about the nature of the task and the workings of the Federal government recommends that the Congress establish a temporary National Weather Modification Commission "to develop a national policy on weather modification." Within the Commission framework each pertinent Federal agency would be represented.

I hope your committee will have fruitful hearings in Mid-June.

Sincerely yours,

EARL G. DROESSLER, *Dean for Research.*

UNIVERSITY OF WASHINGTON,
DEPARTMENT OF ATMOSPHERIC SCIENCES,
Seattle, Wash., May 28, 1976.

Mr. FRANK R. HAMMILL, Jr.,
*Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.*

DEAR MR. HAMMILL: In reply to your invitation of May 21, 1976 I am glad to submit the attached statement on H.R. 10039 and S. 3383. This statement is a brief summary of my views on the need for a national policy in weather modification which have been developed through close association and study of the field over an extended period of time. Your staff may be interested in a study of this subject which I headed and which was distributed by the American Meteorological Society to all Members of Congress in 1974. The reference is: Fleagle, R. G.,

J. A. Crutchfield, R. W. Johnson, M. F. Abdo, 1974, "Weather Modification in the Public Interest," University of Washington Press, 88 + pp.

This report discusses in detail the history of weather modification, the social impacts, and alternative ways to achieve a more effective program.

Sincerely yours,

ROBERT G. FLEAGLE, *Chairman.*

Attachment.

STATEMENT ON H.R. 10039 AND S. 3383 BY ROBERT G. FLEAGLE, CHAIRMAN, DEPARTMENT OF ATMOSPHERIC SCIENCES, UNIVERSITY OF WASHINGTON

Controversy has surrounded weather modification for more than 30 years. As a result of research in this period much has been learned about the physics of clouds and precipitation processes, but our ability to modify weather for useful purposes has increased little. The most important capability demonstrated to date is to increase seasonal snowfall over mountains in the west by about 15 percent. This capability was demonstrated by a joint university-government research program in 1953; and despite many efforts to improve the effectiveness of seeding techniques, the results of recent tests in this country and in other countries appear to be no greater. Nevertheless, on the basis of this experimental result, studies have shown that the economic value of water which might be produced through operational programs should exceed the costs of seeding by factors which range from about 3 to 30. It appears therefore, that deliberate augmentation of winter orographic precipitation might be of substantial economic value, and it is likely that improved understanding of the detailed characteristics of individual storms could lead to much greater benefits. However, we still do not know everything we should about downwind effects; if these effects should turn out to be significant the calculation of net benefits might be much more complex than has been recognized.

Seeding to increase precipitation from cumulus clouds and from cyclonic storms over flat terrain has not been proven to be economically significant, reduction of winds in hurricanes has not yet been convincingly demonstrated, and hail suppression remains a research and not an operational enterprise.

What has prevented greater advances in weather modification and what must be done to rescue this potentially valuable technology from endless frustration? It is important to recognize that the physics of clouds and precipitation is complex and difficult, requiring the best in scientific talent and facilities. But in addition, progress has been constrained by the administrative weather and climate which has influenced national policies over the years. Studies by the National Academy of Sciences, the National Advisory Committee for the Ocean and Atmosphere, and the General Accounting Office have identified the major policy deficiencies which must be rectified if we are to develop a research program of the needed quality and scale.

The most important policy defect is that, although development of capabilities to increase water supplies by cloud seeding or to modify hurricanes would have clear and substantial impacts on national policies relating to food, energy, and natural hazards, a National Program does not exist. There is no lead agency, and each agency pursues a separate course determined, at best, by its separate mission. An example of what happens in the absence of national policy was provided in January 1973 when, in response to extensive budgetary impoundments by OMB, five of seven weather modification programs which had been identified by the Federal Council as National Projects were arbitrarily terminated or suspended.

A second defect is that the separate weather modification statutes adopted by about 30 states are inconsistent and, in some cases, contradictory. As a result, it is possible for field programs in one state to influence neighboring states and to contaminate experimental results.

A third defect is that although there are important international dimensions of weather modification, they have been ignored for the most part. Military use of weather modification, even if it is ineffective, produces international suspicions which could jeopardize important scientific programs as well as other aspects of foreign policy. Hurricane modification poses possible dangers to nations which might be affected by the hurricanes. U.S. commercial cloud seeders operate in foreign countries often with little supervision.

The foregoing is a brief statement of the need for developing a coherent national policy for weather modification. With respect to the bills before this Com-

mittee, I believe S. 3383 would be a positive first step in developing such a policy. H.R. 10039 is a more detailed bill requiring more discussion. The bill appears to be based on the view that profitable applications of weather modification techniques are assured and are within easy reach. As my earlier discussion has indicated, I feel that this is unrealistic and I should like to suggest a few changes. Under Title I the critical importance of developing a strengthened research program should be emphasized, and the responsibility for inter-agency coordination of research activities should be specified. Title III extends weather modification reporting requirements to include federal agencies, thereby contributing substantially to an improved system of information relating to weather modification activities. This is important, especially in bringing military agencies within the information system. The language of the bill might explicitly recognize that the Department of Commerce has established a reporting system under P.L. 92-205. With these changes I believe both bills would be helpful in developing an effective weather modification program which would serve the public interest.

SYRACUSE UNIVERSITY RESEARCH CONSERVATION,
Syracuse, N.Y., June 1, 1976.

MR. FRANK R. HAMMILL, JR.,
*Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.*

DEAR MR. HAMMILL: Thank you for your letter of May 21 asking me to comment on H.R. 10039 and S. 3383. I have had a long-standing interest in the subject of weather modification and am pleased to have the opportunity to state my views on the public policy aspects of this field. In doing so, I shall limit my statement to domestic, civilian issues.

Both H.R. 10039 and S. 3383 serve a very useful purpose in focusing attention on a genuine need: the need for national policy in weather modification. Such a policy would seek to balance interests in advancing the technology through research, development, and demonstrations, while directing and regulating the uses of the technology in the public interest. Such a policy does not exist today. There is a vacuum in national policy.

The vacuum is being filled by a myriad of often conflicting policies made by various federal, state, and local agencies, as well as private-sector institutions—each following its own self-interest as it sees that interest. We have partial policies, fragmented programs, and piecemeal approaches. The result is that the whole is less than the sum of the parts. The lack of national policy has led to the following consequences: (1) The development of the technology is moving at a snail's pace; (2) the use of the technology is encouraged by some states and discouraged by others; and (3) the public is thoroughly confused as to the genuine capacities and potentials of the field.

Weather modification requires a coherent national policy. I say this not because I am enamoured of weather modification for its own sake, but rather because it could be a useful tool in mitigating serious weather-related problems facing the country.

As all of us are aware, these problems include drought, hurricanes, tornadoes, hail, lightning, fog, floods, and frost. They cause untold human suffering in loss of life and property. Moreover, there is evidence that the nation faces a serious water shortage in the future, perhaps even a crisis in certain chronically-parched regions of the country. Finally, we are coming to be increasingly aware of how much the world depends upon the United States as a food supplier. As population continues to expand and mass starvation comes more and more into the consciousness of the individual American, so also will food production—and the problems affecting production—become a major national issue. Weather, of course, is a pervasive determinant of food production.

Thus, I am persuaded the nation would be well advised to anticipate a need for options in fighting weather-related problems. Weather modification is not the only option that could be available, but it is one that could be helpful—if properly developed and applied in a responsible manner. This depends, of course, not upon some invisible force of technological determinism but upon conscious human will. This would hopefully be a will guided by a carefully formulated national policy. Such a policy would strengthen weather modification as a technology while also controlling its use. It would have two major aspects: technology development and technology utilization.

With respect to development of the technology, the role of the federal government is clearly dominant. The federal government is the primary sponsor of research and development for weather modification. For a variety of reasons, there is little expectation that private industry, much less state and local government, will provide more than a small fraction of the funds needed to accelerate development. This is especially the case for the basic research that may be required to undergird the more applied, developmental aspects.

On the basis of other efforts to develop new technologies, it can be seen that there are three key elements required in a national policy: goals, organization, and money. The goals give substance to national decision. They say what it is the nation wishes to do. These goals can be exceedingly clear-cut, as in the decision to go to the moon, or more vague, as in energy independence. But there should be goals, and these goals should permit the establishment of subgoals: short-range, intermediate, and long-range. From such goals derives a strategic approach to R. & D.—a commodity whose absence is the rule for most federal science and technology efforts.

If goals declare "what" is to be done, administration sets the "how." Nothing is more lamentable than ambitious and bold goals that are not backed up by an administrative organization with the capacity to carry them out. Implementation is extraordinarily difficult in any event, due to the uncertainties that are implicit in R. & D. It is made virtually impossible if an administrative framework is not provided by which those goals can be executed. Such a framework requires one agency to have "lead" responsibility for technological development. What "leadership" means is control of the direction and priorities in an overall program of research, development, and demonstration projects. There is dispute within the Federal bureaucracy today as to which agency should have that responsibility, and a national policy for weather modification will have to resolve the issue in favor of one or another agency. It must then provide the agency the resources to lead, in fact instead of merely on paper. This brings up the question of money. Goals, organization—these avail little without financial support. How much is enough for weather modification? That is clearly a question that shows most directly where science and politics meet in today's world. What can be done is not necessarily what should be done, given the other needs pressing on American taxpayers. Levels of funding must be set—a political decision. But they should be set with a consciousness of how a given level impacts on the pace of the field. The most remarkable dimension of the Apollo program, for example, was not the setting of the lunar goal. It was not its implementation by NASA. It was the fact that the goal and organization were maintained by successive administrations and Congressional majorities. They provided funds in pace with a desired end.

Having used the Apollo analogy, let me emphasize that the strategic approach does not require any particular state of readiness on the part of a given science or technology. "Strategic" refers to a state of policy and public management, really a state of mind on the part of political and bureaucratic decision-makers. What is strategic for certain fields of weather modification (e.g., snowpack augmentation) may not be for another (e.g., tornado control). The best strategic approach for some parts of weather modification may be simply enlarging the amount of funds given basic research and the training of scientific manpower. The worst may be putting all the money into applied field experiments. However, even basic research requires goals, organization, and money, if it is to be placed in a framework that leads toward the eventual advancement of a technology. The researcher may be pursuing cloud physics for its own sake, but the government should be sponsoring him for his contribution to a broader, societal goal.

The other major segment of a national weather modification policy relates to the operational utilization of the technology. A national policy toward operations should guide the way the technology is used. This involves a rather difficult balancing of interests in promotion and control. It also entails blending Federal concerns for monopolizing policy for some weather modification applications, while allowing other applications to be controlled by non-Federal organizations and individuals.

Promoting the uses of weather modification should be left to those public and private entities that have missions related to specific uses, such as enhancing water resources in the West or agricultural productivity. While the advancement of a new technology requires concentrated Federal attention, the actual promotion and introduction usually necessitates a more pluralistic administrative strategy. A strategic national policy for weather modification would involve the users in the planning of the technology's development, especially at the stage

where demonstration projects are to be attempted. Eventually, when technology and policy are ready, the users would take over from the developers full responsibility for operations.

Who the user of the technology would appropriately be would depend primarily on the nature of the application, particularly its scale of impact. For large-scale applications, such as hurricane modification, the Federal Government is the only appropriate user. For those involving smaller-scale applications, such as rain augmentation in a county, the State and/or local government or even a private association might be an appropriate user. Use, however, should not take place without regulatory controls.

Who should regulate? Weather modification technologies have been in being for some years. In the absence of Federal policy, States have moved ahead to set up their own agencies to oversee the use of the technology within their borders. Some States regulate rather strictly; others are more liberal. While differences among the States may be appropriate, they should not be permitted to override national interests either in promoting or controlling the uses of the technology. Moreover, here are many applications of weather modification that now or in the future are likely to spread beyond the jurisdictions of a single State. I would, therefore, favor a national regulatory policy and the eventual establishment of a Federal regulatory agency for weather modification. Such an agency might be wholly new, or it might be a new component of an existing organization, such as the Environmental Protection Agency. The principal of checks and balances would argue that the agency regulating not be part of the same one that is developing or promoting the technology.

Stated above have been certain ideas that set forth a strategic approach to advancing and managing weather modification in the public interest. Such an approach may seem extreme, but I would argue that the absence of strategic policy leads to de facto policies being set anyway—by individual bureaucracies, States, localities, and the private sector. Policies are being made at the moment. They are setting the pace and direction of the technology's development and use. This is being done without any sense of an overriding national purpose or perspective on the field.

While H.R. 10039 has many points I find commendable, my preference is that Congress enact S. 3383. I think a systematic study of where we are and where we wish to go in weather modification should precede a major Congressional enactment. My only reservation is that the study be under the guidance of the National Science Foundation rather than the Department of Commerce. To the extent the question of leadership in a national program is addressed in the proposed study, Commerce would be viewed in some quarters as less than unbiased as to "who" should be the lead agency. NSF, in contrast, is generally regarded as a more neutral agency where the question of weather modification jurisdictions is at issue.

It is possible, of course, that the study will lead to a conclusion that the strategic approach is out of place in view of the state-of-the-art of weather modification. Or it might suggest that weather modification presents a remarkable opportunity to establish a strategic and anticipatory policy for a field that is yet emerging. The notion of putting policy before technology is, to be sure, novel. But it would be a refreshing change from the reactive modes by which we generally make our science and technology decisions in the United States.

Again, thank you for offering me the opportunity to comment on the proposed weather modification legislation and policy.

Sincerely,

W. HENRY LAMBRIGHT, *Director.*

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
DEPARTMENT OF METEOROLOGY,
Cambridge, Mass., June 2, 1976.

Mr. FRANK R. HAMMILL, JR.,
Committee on Science and Technology, U.S. House of Representatives, Washington, D.C.

DEAR MR. HAMMILL: Thank you for inviting me to submit a statement for the record of the hearings on H.R. 10039 and S. 3383 by the Subcommittee on the Environment and the Atmosphere.

I have been engaged in teaching and research on meteorology at the Massachusetts Institute of Technology for some 45 years. My special area of interest

is cloud physics and I have closely followed modern developments in weather modification since their inception in 1947. However, I have not been personally engaged in any of the resultant weather modification experiments.

In spite of nearly 30 years of research and field trials, uncertainty persists as to the conditions under which cloud seeding will yield increases in precipitation. Indeed, some of the best-controlled field trials have apparently decreased the precipitation. Undeniably, we have learned much about precipitation processes and it has been demonstrated in a few locations that cloud seeding has yielded modest increments of precipitation. However, it is my opinion that the great majority of the field trials conducted over the past two decades have provided little return for the money spent either in the form of useful precipitation or in advancing scientific knowledge. In my opinion this has resulted from a too-simplistic approach to an extremely complex problem. The hypothesis has been that precipitation is released primarily through the ice phase, that nature often fails to provide a sufficient number of ice particles and that, therefore, the introduction of artificial ice nucleants will lead to increased precipitation. The hypothesis is tested by means of statistical evaluations of the rainfall received at the ground. We have learned that the natural variability of rainfall is so great that a very long series of trials is required to yield statistically significant results. Even then the statistical results yield little or no knowledge of the physics of the precipitation process which might lead to improved techniques and a means for transferring the results of the trials to other areas. We must not continue to support field trials of this sort.

I suggest that we should set up a field project designed to observe all pertinent aspects of the precipitation process before even considering its modification. This will be a difficult and costly project but we must know when, how and where the ice phase appears, in what concentration and how it participates in the growth of precipitation particles. Only then can one intelligently assess the prospects for useful modification by means of ice nucleants and determine the requisite timing, location and concentration of the nucleant injection. When seeding is performed, it must be followed by direct observations to determine if it behaves as expected, for example, if the concentration of ice particles increases as planned.

Such a field experiment would require a number of instrumented aircraft, advanced radars and modern sounding systems. Several years would doubtless be required and the site should probably be changed at intervals to explore different types of precipitation systems. It will be argued by some that such detailed explorations have already been made but I contend that it has never been done in the integrated and detailed fashion that I propose. If it had, we would know what is needed to get the maximum benefit from weather modification and we clearly do not. Lest it appear otherwise, I am optimistic that cloud seeding will be of considerable social and economic value once it is based on sound scientific knowledge.

In my opinion there are already so many reviews of weather modification extant that another as proposed in S. 3383 is unnecessary. I am inclined to believe that further legislation at the Federal level is not needed now. No matter how benign its intent, regulation may unnecessarily inhibit progress in presently un- contemplated directions.

The views I have expressed are my own and are not to be considered as representing the opinions of the Department of Meteorology, nor of the Massachusetts Institute of Technology.

Sincerely yours,

HENRY G. HOUGHTON,
Professor Emeritus of Meteorology.

UNIVERSITY OF VIRGINIA,
DEPARTMENT OF ENVIRONMENTAL SCIENCES,
Charlottesville, Va., June 8, 1976.

Mr. FRANK R. HAMMILL, Jr.,
Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.

DEAR MR. HAMMILL: In response to your letter of May 21, 1976, I go on record in opposition to S. 3383.

Although the objectives of the bill are in the national interest, firstly the proposed budget and time frame are inadequate. Secondly, the work should be

by an impartial group of experts outside of the Government rather than by, or reporting to, one of the Federal Agencies with a weather or weather modification mission. A congressionally appointed commission, in my opinion, would be a more useful mechanism to achieve the objectives stated in the bill.

Sincerely yours,

JOANNE SIMPSON,
Professor of Environmental Sciences and Member.

UNIVERSITY OF VIRGINIA,
DEPARTMENT OF ENVIRONMENTAL SCIENCES,
Charlottesville, Va., June 8, 1976.

MR. FRANK R. HAMMILL, JR.,
*Counsel, Committee on Science and Technology, U.S. House of Representatives,
Washington, D.C.*

DEAR MR. HAMMILL: In response to your letter of May 21, 1976, I go on record in opposition to H.R. 10039. I believe that Federal regulation of weather modification is premature. Presently most states are performing, or can perform this function adequately.

In particular, H.R. 10039 has two features that would virtually wipe out the private sector in weather modification. This adverse effect upon the private sector would, in my opinion, be against the national interest. The damaging requirements are those for daily reporting and, most serious, the requirements which appears on page 9 to furnish a bond.

I believe that there are far better alternative methods to advance sound weather modification and to prevent careless or unsound attempts than the mechanism proposed by H.R. 10039.

Sincerely yours,

JOANNE SIMPSON,
Professor of Environmental Sciences and Member.

SOUTHERN CALIFORNIA EDISON CO.,
Washington, D.C., June 22, 1976.

HON. GEORGE E. BROWN, JR.,
*Chairman, Subcommittee on Environment and the Atmosphere, Committee on
Science and Technology, Washington, D.C.*

DEAR MR. CHAIRMAN: It is our understanding that the House Subcommittee on Environment and the Atmosphere of the Committee on Science and Technology has the subject bill under study and has scheduled hearings to be held on June 15-18, 1976. As Chairman of this Subcommittee, we think it is appropriate that we express our views to you on this matter.

Southern California Edison Company is an investor-owned public utility furnishing electric service to nearly 8 million people in Central and Southern California, in a service area of approximately 50,000 square miles. Edison has approximately 12,520 MW of generating capacity, of which a relatively small but vital portion is comprised by hydro-electric generating facilities located on the west slope of the Sierra Nevada Mountains in Central California.

In conjunction with these hydro-electric facilities, Edison has been the sole sponsor of what is regarded as the longest continuous weather modification program in this country. This program has continued since 1951, with minor changes dictated by state-of-the-art technology.

We recommend your support in securing final passage and implementation of S. 3383 and offer the following comments in relation to this and other pending or future weather modification legislation.

Proponents of weather modification have for many years unsuccessfully sought legislation similar to S. 3383, except for responsibility for implementation to be vested in a Commission composed of knowledgeable scientists from government agencies, academic institutions and private industry rather than the Secretary of Commerce. We anticipate that under S. 3383 the National Oceanic and Atmospheric Administration will become the lead agency in national weather modification. Although the Secretary is directed by S. 3383 to "solicit and consider the views of State agencies, private firms, institutions of higher learning and other interested parties and governmental entities" in conducting the studies required by Sections 4 and 5, it has been generally feared within the Weather Modification Industry that NOAA would, in keeping with its reputation for building an internal organization to accomplish all given tasks "in house", pro-

ceed to develop an organization attempting to parallel the expertise presently available within other governmental agencies, universities and private groups thus creating an unnecessary delay in achieving the stated goals and compounding the costs to taxpayers.

It is hoped that a clearly stated national policy arising from S. 3383 will identify the social, economic and ecological benefits which will result from the intelligent application of weather modification technology as a routine practice in addition to its more spectacular use in drought relief, severe storm abatement and other emergency situations.

Most, if not all, existing and proposed weather modification projects in the Western United States are located on or target federally administered lands. We believe it to be a proper and in the national interest for the Congress to declare and define a national policy for weather modification rather than to leave basic policy decisions to the discretion of local administrators of these federal lands, perpetuating the plethora of conflicting interpretations and administrative actions nurtured by an unstated policy.

Beyond the scope of the present S. 3383, we recommend that you consider future legislation that will provide a mechanism for recognizing and defining the priorities and rights of conflicting weather modification projects.

In addition, federal legislation clarifying the conflicting jurisdictions which may occur in intrastate projects and establishing a licensing program to recognize minimum standards for projects and project operators to protect both the public and the legitimate project operators is, in our view, desirable.

Very truly yours,

ALAN M. NEDRY, *Special Counsel.*

HAPPY HEREFORD RANCH,
Happy, Tex., July 19, 1976.

FRANK R. HAMMILL, Jr.,
*Counsel, Committee on Science and Technology,
U.S. House of Representatives, Washington, D.C.*

I want to thank the committee on science and technology for the chance to put my observation on record. I taught physics at Texas Tech University for five years and did some research in physics during that time.

I support Representative Evans H.R. 10039 bill on weather modification. I think the penalties should be stiffer. We have a ranch 15 miles north of a target area and a farm in the target area of a total acres 30,000. Our rain has been reduced some of the summer months to zero, during 1970 the three summer months was zero. 1975 two of the three months were zero.

Due to the decrease in rainfall during the summer months we grew very little grass for the cattle and it made us have to buy more during the winter. Last year it cost us an increase of approx. \$100,000 for additional feed. The family have lived on this place since 1928. During this time there has been three times that there was no fall wheat pasture and it has happened twice in the last six years. They are making semi-desert out of this area.

I think there should be a state meteorologist observing the weather modification as it takes place so they will stay in the area they are assigned.

The people should have a right to vote on the area that they are going to fly and modify the weather. The people voted in this area two to one against hail suppression and yet they were given a permit.

NOLON HENSON,
President of Citizens for Natural Weather.



REPORT TO THE CONGRESS

Need For A National Weather
Modification Research Program

B-133202

Multiagency

*BY THE COMPTROLLER GENERAL
OF THE UNITED STATES*

AUG. 23, 1974



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-133202

To the Speaker of the House of Representatives
and the President pro tempore of the Senate

This is our report entitled "Need for a National Weather Modification Research Program." Weather modification research activities are administered by the Departments of Commerce and the Interior, the National Science Foundation, and other agencies.

Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U. S. C. 53), and the Accounting and Auditing Act of 1950 (31 U. S. C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of Agriculture; the Secretary of Commerce; the Secretary of Defense; the Secretary of the Interior; the Secretary of Transportation; the Director, National Science Foundation; and the Administrator, National Aeronautics and Space Administration.

A handwritten signature in cursive script, reading "Elmer A. Staats".

Comptroller General
of the United States

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ABBREVIATIONS

| | |
|-------|--|
| GAO | General Accounting Office |
| ICAS | Interdepartmental Committee for Atmospheric Sciences |
| NACOA | National Advisory Committee on Oceans and Atmosphere |
| NAS | National Academy of Sciences |
| NOAA | National Oceanic and Atmospheric Administration |
| NSF | National Science Foundation |
| OMB | Office of Management and Budget |

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NEED FOR A NATIONAL WEATHER
MODIFICATION RESEARCH PROGRAM
Multiagency B-133202

D I G E S T

WHY THE REVIEW WAS MADE

Weather modification research is part of an attempt to understand the atmosphere of the earth and other planets. Through this research, which is primarily federally supported, it may be possible to alleviate drought, reduce destructive forces of hurricanes, suppress lightning and damaging hail, and dissipate fog.

During fiscal year 1974 seven Federal departments and agencies--Agriculture, Commerce, Interior, Defense, Transportation, the National Science Foundation, and the National Aeronautics and Space Administration--conducted weather modification research.

Estimated cost for this research increased from about \$3 million in fiscal year 1959 to about \$17.4 million in fiscal year 1974.

Because of multiagency participation and increased Federal support, GAO reviewed the administration of weather modification research.

FINDINGS AND CONCLUSIONS

For nearly a decade, studies of the administration of Federal weather modification research have identified common problems hindering progress:

- No central authority to direct Federal departments efforts.

- Ineffective coordination.

- Insufficient resources to achieve timely, effective results.

Most studies proposed a national program to resolve the problems. (See pp. 7 to 15.)

The Interdepartmental Committee for Atmospheric Sciences, part of the Federal Council for Science and Technology, is responsible for identifying opportunities for improving atmospheric sciences programs. It, however, has no authority to direct Federal research programs. (See p. 4.)

The Committee's efforts to establish a national weather modification research program have not been successful.

In 1966, the Committee recommended that a single agency assume responsibility for developing a national weather modification program. This suggestion was not implemented. (See p. 15.)

In 1971 the Committee recommended that national weather modification research projects be established to accelerate progress by bringing together resources of agencies performing similar research.

Seven major research areas, along with suggested lead and participating agencies, were identified. Each lead agency was to create a coordinating

committee of representatives from participating agencies which would develop plans and submit progress reports to the Committee. (See p. 15.)

GAO found, however, that the recommendations resulted in little change in multiagency participation or in general project administration. (See pp. 15 to 18.)

The National Hail Research Experiment, identified as a major research area in the 1971 Committee report, was already planned as a coordinated effort with the National Science Foundation as lead agency.

Even though the Experiment was well planned, requiring extensive inter-agency participation, GAO found, in comparing planned efforts with actual efforts that, for the most part, agencies could not and did not meet all their obligations.

For example, during the Experiment's first operational season (summer 1972):

--Agriculture planned to assess crop damage from hail and study the economic effects of hail suppression. The Foundation, however, had to subsequently fund the later study. Also, Agriculture could not coordinate and direct the Experiment's electrical studies as planned. (See p. 19.)

--Commerce did not furnish radars and all aircraft as planned and was able to provide technical ground work only with the Foundation's funding. The unanticipated Commerce request for funds caused the Foundation to cancel other items in the program plan. (See pp. 19 and 20.)

--Defense did not furnish helicopters as planned but did provide personnel. (See p. 20.)

--The Atomic Energy Commission could not have provided technical assistance without the Foundation's funding. (See p. 20.)

--Transportation provided personnel as planned. (See p. 20.)

In the most recent operating season (summer 1973), the Foundation had similar problems obtaining support from the agencies participating in the Experiment. (See pp. 20, 27, and 28.)

A national weather modification research program, administered and maintained by a lead agency, is needed to effectively administrate fragmented Federal weather modification research activities. The program should include goals, priorities, and plans for allocating resources to meet priority objectives.

RECOMMENDATIONS

GAO recommends that the Office of Management and Budget should, in cooperation with the Federal departments and agencies involved in weather modification research:

--Develop a national program with goals, objectives, priorities, and milestones, designating one of the agencies, which would have a major program responsibility, to administer and maintain the national program.

--Develop a plan to define and re-assign, if appropriate, the

- responsibilities of Federal departments and agencies providing support or conducting weather modification research.
- Develop a plan to allocate resources to the national program elements.

AGENCY ACTIONS AND UNRESOLVED ISSUES

Most of the agencies acknowledged administrative and management problems in weather modification research but, except for Commerce, did not agree with GAO's recommendations for a national program.

The Office of Management and Budget believed some consolidation of weather modification research was desirable and that proposed legislation to establish a Department of Energy and Natural Resources would accomplish the appropriate degree of consolidation. (See p. 23.)

Commerce, although agreeing with GAO's recommendations, also commented that proposed legislation would bring together many of the widely scattered elements in Federal weather modification programs. (See p. 23.)

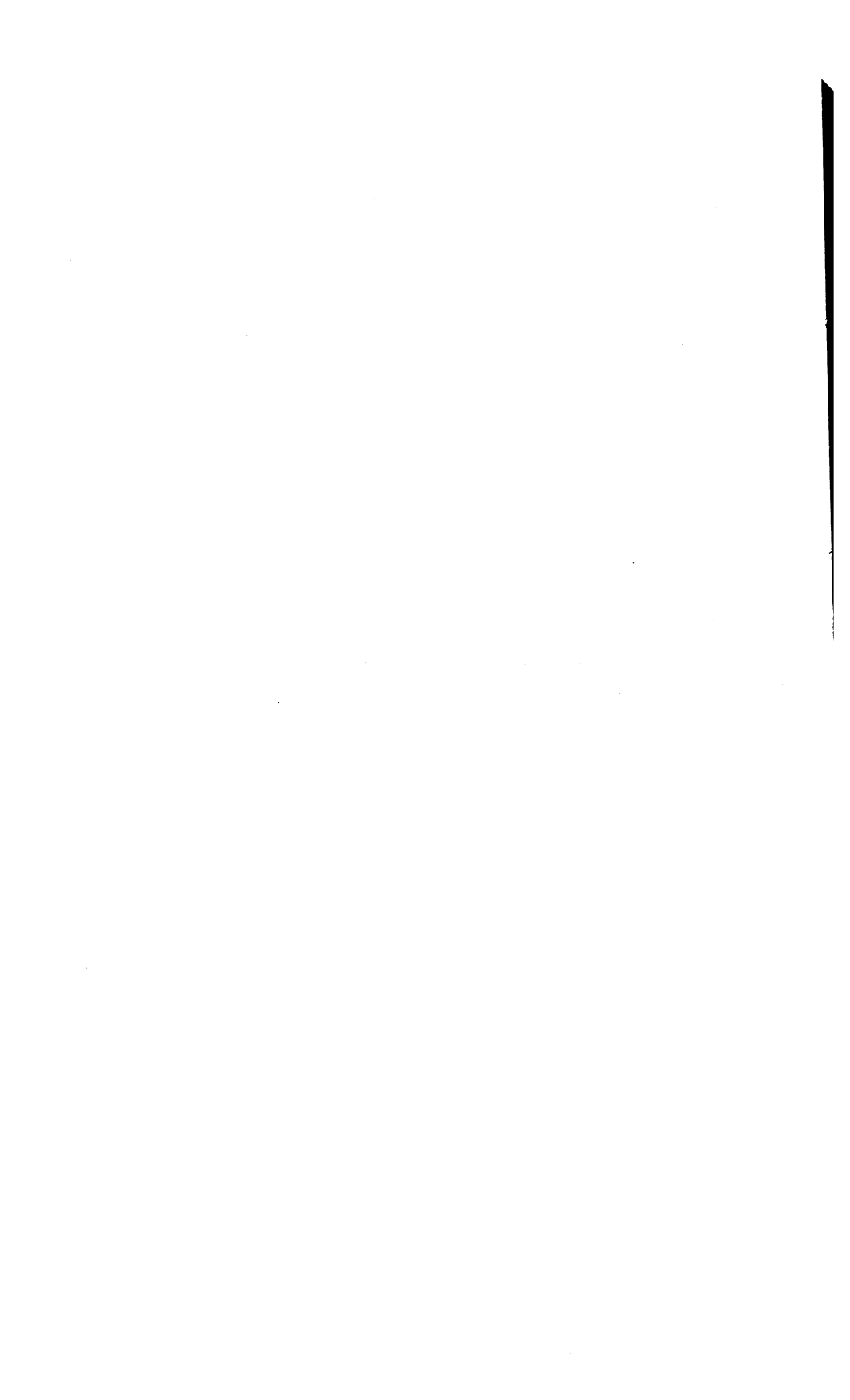
The legislation would transfer three agencies' weather modification activities to the proposed department. In GAO's opinion, problems of administration and management would continue because weather modification activities would still be fragmented. (See p. 23.)

Agriculture, Defense, Interior, and the Foundation generally supported the Committee's lead agency approach. Their comments on GAO's recommendations, which in some cases were shared by the Office of Management and Budget, and GAO's evaluation are on pages 24 to 29.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Because of longstanding problems caused by a fragmented Federal organization for carrying out weather modification research, a national program is necessary to effectively administer activities.

This report should be useful to the Congress in considering the proposed legislation creating a Department of Energy and Natural Resources, which would not totally consolidate Federal weather modification research.



CHAPTER 1INTRODUCTION

Weather modification research is part of the atmospheric sciences which is devoted to understanding the composition and processes of the earth and other planets' atmospheres. The Federal Government supports atmospheric research in three program areas:

- The meteorology area covers the lower atmosphere that extends from the surface of the earth to 100 kilometers, about 62 miles.
- The aeronomy area, which overlaps to some extent with meteorology, extends from outer space to approximately 50 kilometers, about 31 miles above the earth's surface.
- The planetary area is concerned with studies of other planets' atmospheres.

Weather modification research is primarily part of the meteorology area and includes:

- Precipitation modification --to study and develop techniques to manage and control rain or snow.
- Fog and cloud modification--to study and develop methods to dissipate cold and warm fogs.
- Hail suppression --to develop techniques to eliminate hail or reduce the size of hailstones.
- Lightning modification --to determine the basic characteristics of fire-setting lightning storms and develop techniques to suppress or modify lightning discharges.
- Hurricane and severe storm modification --to determine the extent which hurricanes can be beneficially modified.
- Inadvertent modification --to monitor atmospheric constituents and study their modifying influences on the weather.

Science lacks the knowledge to answer many of the questions on weather modification. For example, a thorough understanding of how clouds create rain and snow has not been obtained. In addition, it is not known with a satisfactory degree of confidence to what extent man is changing the climate of the earth. There is wide, though not universal, belief that weather modification has great potential for public good. If weather modification research, which is primarily federally supported,

proves successful, it may be possible in future years to alleviate drought, reduce the destructive forces of hurricanes, suppress lightning and damaging hail, and dissipate fog.

During fiscal year 1974, seven of the nine Federal departments and agencies conducting atmospheric sciences research were involved in weather modification research: the Departments of Agriculture, Commerce, Defense, Interior, and Transportation; the National Aeronautics and Space Administration; and the National Science Foundation (NSF).

Estimated costs for atmospheric sciences research as reported by the Interdepartmental Committee for Atmospheric Sciences (ICAS) increased from \$36 million in 1959 to about \$274.5 million in fiscal year 1974. During this period estimated costs classified as weather modification research increased from \$3 million to about \$17.4 million. NSF and the Office of Management and Budget (OMB) said much of the general research in atmospheric sciences is also applicable to weather modification.

SCOPE

Our review was directed primarily at obtaining information on Federal weather modification research and identifying opportunities for improvements in administration and management of research programs. It included an examination of records and scientific reports; interviews with officials of the various coordinating committees and Federal agencies, including OMB and the former Office of Science and Technology; and interviews with recognized authorities outside the Federal Government.

We did our work at agency offices and field locations listed below:

- Forest Service, Department of Agriculture.
- National Oceanic and Atmospheric Administration (NOAA),
Department of Commerce.
- Defense Advanced Research Projects Agency, Department of
Defense.
- Bureau of Reclamation, Department of the Interior.
- NSF.
- Federal Aviation Administration, Department of Transportation.

CHAPTER 2NEED FOR A NATIONALWEATHER MODIFICATION RESEARCH PROGRAM

The Federal Government's unsuccessful efforts to coordinate its many research programs in weather modification supports the comment often attributed to Mark Twain: "Everybody talks about the weather, but nobody does anything about it."

Our review of the Federal weather modification research activities supports the findings of nearly a decade of studies. These studies conducted by scientific panels, committees, and other groups all identified common problems--ineffective coordination, fragmented research, and research efforts that are subcritical (funded below the level necessary to produce timely, effective results). Most studies proposed a common solution. What was needed, in essence, was a national research program under a single Federal agency responsible for establishing plans and priorities, obtaining the needed funds from the Congress, managing research efforts, and accounting for the results its programs achieved.

To date, except for the establishment of several coordinating committees, subcommittees, and advisory panels--none of which have the authority to take action to correct problems already identified--an effective overall national weather modification research program has not been established.

We noted that research efforts to date have achieved some beneficial results. Individual agency programs have moved forward in several research areas, but panels, committees, and study groups have characterized results more as slow clarifications of concepts rather than as dramatic new discoveries.

There has also been some progress in developing better methods for coordinating weather modification research, although the results have been somewhat disappointing. A recent attempt to achieve a national effort in one research area--the National Hail Research Experiment--in which several agencies' talents and resources would be pulled together under the direction of a single organization has not been as effective as anticipated. Although several interested agencies initially expressed a desire to participate, they later withdrew or reduced participation due to limited funding or higher priority mission-oriented efforts. (See p. 18.)

If potential benefits of weather modification research are to be obtained, action should be taken now to establish an effective national program with all agencies involved required to work toward achieving national goals and objectives.

FEDERAL ACTIVITIES IN
WEATHER MODIFICATION RESEARCH

In fiscal year 1974 seven departments and agencies were involved in weather modification research. Many of the research efforts were fragmented with as many as three or four departments and agencies funding research programs in precipitation modification, fog and cloud modification, lightning modification, and inadvertent modification.

Much of the fragmentation came about during the late 1940s and early 1950s when agencies were having little success in producing conclusive results in their weather modification programs. They believed that more basic research was needed to fill information gaps. At that same time, potential user agencies, specifically the Department of Agriculture's Forest Service and the Department of the Interior's Bureau of Reclamation, were becoming interested in weather modification as a tool to help accomplish their missions. Eventually, these agencies, plus the others now involved, initiated their own mission-related weather modification programs.

Planned fiscal year 1974 expenditures for weather modification programs (about \$17.4 million) are shown in figure 1. (See p. 6.) Program efforts are discussed in appendix I.

Since 1959 the following primary committees were established to coordinate the programs of agencies involved in atmospheric sciences. None of the committees have the authority, however, to direct these agencies' efforts.

Interdepartmental Committee
for Atmospheric Sciences

On recommendation of the President's Science Advisory Committee, Executive Order 10807 established the Federal Council for Science and Technology in March 1959 which consists of policy-level officials from the Federal agencies principally involved in research and development activities. The Council's function is to provide for more effective planning and administration of scientific and technological programs, identification of research needs, use of resources, and international cooperation in science and technology.

In August 1959, ICAS was established as a committee of the Council to undertake studies and develop recommendations concerning the

- scope and balance of Federal agencies' present and future activities in the field of atmospheric research,
- needs and deficiencies of research programs,
- requirements for and use of specialized facilities,

- allocation of responsibilities among Federal agencies,
- effective coordination of agency programs,
- planning of future programs, and
- encouragement of nongovernmental participation in the field of atmospheric sciences.

Its members, scientist-administrators from the Federal agencies involved, meet monthly. They make recommendations to the Council which, when endorsed, serve as guidelines for participating agencies' budget submissions and as criteria for review by OMB and the Office of Science and Technology. ^{1/}

Federal Committee for Meteorological Services and Supporting Research

In November 1963, OMB issued Circular A-62 entitled "Policies and Procedures for the Coordination of Federal Meteorological Services" which assigned to the Department of Commerce the responsibility to coordinate meteorological services and the research necessary to support them. Also, OMB directed Commerce to prepare a plan to integrate current and future services and research consistent with the effective and economical accomplishment of mission requirements. In response, Commerce established the Federal Committee for Meteorological Services and Supporting Research. The Committee, composed generally of members at the Assistant Secretary level representing the agencies comprising ICAS, meets annually to review and validate the Federal plan.

National Advisory Committee on Oceans and Atmosphere (NACOA)

Public Law 92-125, approved August 16, 1971 (85 Stat. 344), established NACOA which is made up of representatives appointed by the President from industry, science, and State and local governments. NACOA is required to assess the status of marine and atmospheric science programs and report annually to the President and the Congress.

OMB

OMB is responsible, by Executive Order 11541, issued July 1, 1970, for promoting the development of agencies' improved plans and organization; assisting in the development of better interagency cooperation; and

^{1/} On January 26, 1973, the President transmitted to the Congress Reorganization Plan No. 1 of 1973, which transferred all functions of this Office to the Director, NSF. The reorganization, which abolished the Office, took effect July 1, 1973.

FIGURE 1

PLANNED FEDERAL RESEARCH EXPENDITURES IN WEATHER
MODIFICATION DURING FISCAL YEAR 1974
 -----(000 OMITTED)-----

| <u>Departments and agencies</u> | <u>Total</u> | <u>Precipitation modification</u> | <u>Hail suppression</u> | <u>Inadvertent modification</u> |
|---|-----------------|---------------------------------------|-----------------------------|-------------------------------------|
| National Science Foundaticn | \$ 6,600 | \$ 450 | \$3,250 | \$ 700 |
| Commerce | 4,233 | 840 | | 908 |
| Interior | 3,250 | 2,400 | | |
| Defense | 1,594 | | | |
| Transportation | 1,397 | | | 1,304 |
| Agriculture | 293 | | | |
| National Aeronautics and Space Administration | ^b 50 | | | |
| Totals | <u>\$17,417</u> | <u>\$3,690</u> | <u>\$3,250</u> | <u>\$2,912</u> |

^aOther represents research efforts related to mathematical modeling; social, economic, legal, and ecological studies; and support and services.

^bThe administration in reporting its atmospheric science activities to ICAS did not classify any research as weather modification; however, the administration considers \$50,000 of dynamic meteorology as applicable to weather modification.

Source: ICAS Report 17-FY74 (Issued May 1973)

| <u>Fog and cloud modification</u> | <u>Hurricane and severe storm modification</u> | <u>Lightning modification</u> | <u>Other (note a)</u> |
|---|--|-----------------------------------|---------------------------|
| \$ 800 | | \$300 | \$1,100 |
| | \$1,548 | | 937 |
| | | | 850 |
| 1,534 | | 60 | |
| 93 | | | |
| | | 293 | |
| b50 <u>\$2,477</u> | <u>\$1,548</u> | <u>\$653</u> | <u>\$2,887</u> |

evaluating programs for the assessment of objectives, performance, and efficiency. An OMB representative sits as an official observer on ICAS and the Federal Committee for Meteorological Services and Supporting Research.

FEDERAL LEGISLATION ON WEATHER MODIFICATION ACTIVITIES

The spread of private weather modification activity in the United States in the late 1940s and early 1950s raised concern in the Congress about the usefulness and effectiveness of this new technology. The Congress, through Public Law 83-256, approved August 13, 1953, established an Advisory Committee on Weather Control. The Committee was required to study and evaluate public and private experiments in weather control and determine the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions. Its report, issued in 1957, was modestly favorable on the potentials of weather modification and recommended further research.

In following up on the report recommendations, the Congress enacted Public Law 85-510, approved July 11, 1958, which authorized and directed NSF to initiate and support a program of study, research, and evaluation in the field of weather modification, and to report annually to the President and the Congress. In addition to establishing weather modification as one of its research programs, NSF also required all commercial and private weather modifiers to maintain records and submit reports on their activities.

In 1968 NSF's authority under Public Law 85-510 was repealed, apparently on the assumption that it would be reassigned to some other agency during the same congressional session. However, no other authorizing law was passed until Public Law 92-205 was enacted on December 18, 1971. This law required that all nonfederally sponsored weather modification be reported to the Secretary of Commerce.

Since 1966 the Congress has considered several bills concerning the assignment of individual agency authority and responsibility for weather modification and one to prohibit weather modification anywhere in the Nation. None of these bills were passed.

INDEPENDENT STUDIES EVALUATING FEDERAL WEATHER MODIFICATION RESEARCH

For nearly a decade a number of scientific panels, committees, and other groups have reviewed, evaluated, and reported on the status of and problems associated with Government atmospheric sciences programs. In nearly every case the reports, including the most recent issued June 29, 1973, by NACOA have not only cited a need for a national program with centralized, single agency responsibility, authority, and control, but also highlighted problems in coordinating multiagency activities and the lack of progress because of fragmented and subcritical research programs. Several of these reports are discussed below.

"Government Weather Programs (Military and Civilian Operations and Research)"

This report, issued in 1965, was prepared by the Military Operations Subcommittee under the direction of the Chairman, House Committee on Government Operations. Its purpose was to inform the Congress, executive branch agencies, scientific and technical communities, and the general public about the scope and complexities of governmental programs related to weather services and research in the atmospheric sciences.

The report noted that the Congress is familiar with the difficulties of achieving efficient coordination of programs, but multiagency programs present special problems. It stated that:

"Each agency that carries on only part of a Government research program has a difficult task to justify its own particular operations, but it is also hard put to avoid actual duplication of work due to overlapping or parallel activities of other participating agencies. The coordination which can be accomplished by each agency to avoid this is laborious and limited. And while the agencies may be conscientious in trying to avoid waste, they are charged with specific missions.

"Coordination among agencies or bureaus of each executive department is difficult enough, but a field such as the one discussed in this report includes participation not only by several Cabinet departments, but by independent agencies and offices. The weather activities carried on by each may touch the major mission responsibilities of the agency, even though these activities are only a small part of its total effort. If missions are affected, the agency must strike a balance between insuring, as far as it can, that its work goes ahead successfully, and sharing the program area with other interested agencies.

"Within the executive branch, the Bureau of the Budget [now OMB], the Office of Science and Technology, the Federal Council for Science and Technology, and similar groups may try to prepare a more unified 'program package' in an area such as weather research. But short of a Presidential directive to do so, these offices cannot continually monitor particular programs, and they obviously cannot give full-time attention to all programs at once.

"The problem lies in finding economical means for continuous coordination among agencies. Committees, boards, panels, and groups may be formed, but a solution to policy problems, it is frequently said, is not found by forming a committee. Besides, what can be done to force agencies, particularly executive departments, to comply with committee recommendations, when departmental missions appear to conflict with generalized interdepartmentally agreed policy?"

The report noted a large Federal funding for atmospheric sciences research and meteorological services and that problems of administration, coordination, and financial control of the multiagency programs were becoming increasingly apparent. It raised a series of questions in 18 subject areas of potential congressional concern, such as national programs, Federal coordination, and fragmentation of atmospheric sciences research and meteorological services.

"Weather and Climate Modification -
Report of the Special Commission on
Weather Modification"

Also in 1965 a Special Commission on Weather Modification, authorized by the National Science Board, issued its report to the Director, NSF. The Commission, consisting of members primarily from the academic community, had been requested to examine the physical, biological, legal, social, and political aspects of weather modification and make recommendations for future policies and programs.

In commenting on how Federal weather modification activities are administered, the Commission identified duplication in research activities and coordination responsibilities as problem areas. The report stated that, with more agencies in weather modification research, there is a need to establish a Federal organization to accomplish what cannot be done by diverse research activities. The Commission said that, as long as weather modification activities were mainly basic research, duplication was not a major problem, but certain aspects had reached the applied research and operations phase and regulatory activity was not far away. It also said, because no single agency has been assigned the responsibility for developing the technology of weather modification, a definite need to do so existed.

The Commission recommended that the Office of Science and Technology establish

"* * * a special mechanism for the coordination of weather and climate modification programs and for recommending such steps as may be appropriate for effecting a unity of governmental policy in this field."

Also, it recommended that the mission of developing and testing methods for modifying the weather should be assigned to one agency in the executive branch to correct overlap and lack of concerted effort among the various agencies.

"Weather and Climate Modification
Problems and Prospects"

The Committee on Atmospheric Sciences published this report to the National Academy of Sciences (NAS), in 1966. It was the result of a 2-year study by a panel of the Committee which reviewed the present status and activities in this field and its potential and limits for the future.

The panel identified four problem areas in administration and management of weather modification activities.

1. The level of effort was not commensurate with the demonstrated opportunities for further research likely to have early practical implications.
2. The major portion of research resources (money and manpower) was being dissipated by supporting subcritical efforts.
3. Scientific groups were severely hampered by lack of a central management organization with authority and skill to consummate interagency negotiations and operations.
4. ICAS, which in principle has responsibility for coordinating efforts in weather modification, has no power to initiate action within any agency.

The panel concluded that:

- The present support and administrative mechanisms do not provide adequate means for setting priorities among the many large field experiments and projects that will eventually be needed.
- The present fragmentation of effort in weather modification research and development is unusual in that many of the fragments are below critical size or quality needed for effective work.
- Major responsibility for weather modification should be centered in a single agency.

"Weather-Modification Progress and the Need for Interactive Research"

This report, published in October 1968, was prepared by the Weather Modification Research Project Staff, Rand Corporation, under a contract with NSF. The report concluded:

"The structure of the national weather-modification program has not--in one vital respect--been strengthened since the time of our previous study in 1962. We referred to the specific weakness then as a lack of a 'cohesive' approach to weather modification. The NAS Panel on Weather and Climate Modification in 1966 called the same problem a 'fragmentation of effort.' We reiterate it now in terms of the need for more 'interactive research'."

* * * * *

"In 1962 we have concluded, and again in 1968 we are forced to conclude, that the subject of weather modification could

benefit, probably greatly, by a more directive program in which theoreticians as well as experimentalists are guided toward a common and mutually supporting set of goals * * *."

The report recommended establishing a weather modification research organization, either by creating a new organization or by strongly augmenting any of several existing groups, to apply all possible advances in atmospheric science and engineering competence to the design of research and experimental programs in weather modification.

"The Atmospheric Sciences
and Man's Needs"

In 1971 the Committee on Atmospheric Sciences, NAS, issued another report which stated that:

"* * *determination of priorities for investment in atmospheric research and its application has become extremely difficult. Resources are not adequate to support all scientifically valid and useful programs. * * * Priorities will have to be determined."

* * * * *

"* * *FCST [Federal Council for Science and Technology] and ICAS have not been able to develop an integrated national program in weather modification. Individual agency programs have been subcritical in size and research capability. ICAS has no authority to consolidate or to modify agency programs; and, most important, ICAS is not able itself to mount research efforts, no matter how badly needed they may be. Agency initiatives at the scientist level, even though endorsed by ICAS, may not be approved by agency administrators; and agencies may launch major programs without ICAS endorsement. The result has been that in important respects the national effort in weather modification has been largely dissipated in submarginal projects, while crucial problems requiring large programs remain unsolved."

In considering how to best solve this problem, the report noted the following.

- Responsibility for research in weather modification must be closely associated with responsibility for research in the atmospheric sciences generally.
- National policy in weather modification must be based on full consideration of relevant economic, social, ecological, and legal factors, as well as scientific and technical factors.

The report concluded that a suitable administrative solution consistent with these requirements would be to make a single agency responsible for research in weather modification and for coordinating major field programs.

First and second annual reports--National
Advisory Committee on Oceans and Atmosphere

NACOA's first annual report was issued on June 30, 1972. Concerning ongoing national projects in weather modification, such as the voluntary combinations of several Federal agencies' resources the report stated:

"* * *Thorough 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 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."

* * * * *

"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."

* * * * *

"What is lacking is a central focus for the overall effort. * * *[There] 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."

NACOA's second annual report was issued on June 29, 1973. The report repeated its previous year's recommendation that the small weather modification research programs scattered widely through the Federal agencies be coordinated and provided with a central focus. The report stated:

"* * *What NACOA found lacking is a central strategy for the overall research effort. * * * We had recommended increasing the NOAA lead role because it possessed the bulk of the capabilities required. We regret to note that this has not taken place, and further, that a step has been taken in the opposite direction--the assignment of lead responsibility for precipitation enhancement was transferred from NOAA in Commerce to the Bureau of Reclamation in Interior."

* * * * *

"* * *the dispersive forces serving to fragment the program are strong. We feel that a formal lead agency assignment is desirable and that NOAA is the appropriate candidate.* * *"

The Committee's annual reports are submitted to the Secretary of Commerce who, within 90 days of receipt, transmits copies to the President and the Congress, with his comments and recommendations.

In his comments on the first annual report the Secretary agreed with the recommendation to establish a central focus in the Government for carrying out research and development in all phases of weather modification. However, he stated that it would be unwise to divorce the necessary supporting research, required for the application of weather modification techniques, from the agency responsible for such application. The Secretary, in commenting on the second annual report, said that Commerce interpreted the Committee's advice as not precluding agencies' need from carrying out operational and research activities closely related to their missions. He also commented that one of the benefits of establishing the proposed Department of Energy and Natural Resources will be to permit new opportunities for more effective planning and coordination and management of weather modification activities. See page 23 for our comments on the proposed new Department.

"Weather and Climate Modification
Problems and Progress"

This 1973 NAS report was a followup of the 1966 NAS report to determine weather modification progress since the earlier study. The report reaffirmed the earlier conclusion that a single agency should be responsible for weather modification. It stated that:

"* * *Finally there is a function to be provided by an agency that has the scientific and management competence, the dedication, and the resources to make the national goals cited earlier an integral part of its basic mission. It is precisely this function that has been conspicuously absent in the Federal government and is an important reason that progress has not been more rapid."

* * * * *

"* * *The responsibilities of these various agencies in the field of weather modification research need to be defined more carefully. A recent effort at defining these responsibilities was made by ICAS in proposing to the Federal Council of Science and Technology steps to 'accelerate progress in weather modification.' A more definitive specification is needed, combining both responsibility and authority to develop a national program in which basic, applied, and experimental efforts are carried out in an integrated manner.

"With due consideration to the missions of the several agencies, their capabilities for supporting research in weather modification and their present activities in the field, we recommend that the National Oceanic and Atmospheric Administration be assigned

principal administrative responsibility for a national program in weather modification. * * *

The report also stated that many weather modification projects still remain below critical size, which also was one of the conclusions of the 1966 report. The 1973 report stated:

"In 1966 the Panel on Weather and Climate Modification noted with concern that a major portion of the research resources in weather modification, both money and manpower, was being inefficiently used in the support of subcritical efforts. The same situation holds today. * * * No single agency has primary responsibility at the present time. The special role assigned to the NSF in this field has been removed from it as a result of legislation. The ICAS continues to provide communication among scientists and government. In principle, this body has the responsibility for coordinating efforts in weather modification. However, any agency can bypass the Committee if it so wishes, since no interdepartmental committee has the power to initiate action within a given agency."

ICAS EFFORTS TO ESTABLISH NATIONAL PROGRAMS

In 1966 and again in 1971, ICAS tried to establish national programs in weather modification. Both efforts were unsuccessful because ICAS lacked authority to direct agency involvement in coordinated programs and because mission-oriented agencies had higher priorities.

In March 1966, the Federal Council for Science and Technology asked ICAS to prepare a report on the division of weather modification research responsibilities. The resulting report entitled "A Recommended National Program in Weather Modification" was issued in November 1966.

This report evaluated weather modification program plans, budgets, schedules, staffing, facility construction, and operations of four agencies. Increased funding levels were recommended but never obtained by agencies. Recommendations that a single agency assume responsibility for developing a well rounded national weather modification program, that the Federal Coordinator be assigned the coordinating and reporting responsibility for weather modification, and that Interior and NOAA collaborate on a precipitation modification project were never carried out.

In 1969 the Council again asked ICAS to develop a national weather modification program. The resulting report entitled "A National Program for Accelerating Progress in Weather Modification" was issued in June 1971.

The report concluded that, although weather modification had progressed through the efforts of small and occasionally independent groups, progress could be accelerated by making it easier for these groups to bring together their skills, resources, and mutual interests under an interdisciplinary multiagency approach. It suggested that national projects be established, designating the agency currently performing the major effort in each project as lead agency; that is, the agency responsible for planning and managing the proposed project. Other agencies with similar programs or interests were to participate with the lead agency. Figure 2 on page 16 shows the projects proposed and the designated lead and participating agencies.

In addition, the report recommended that each lead agency create a coordinating committee composed of representatives from participating agencies which would develop action plans and submit periodic progress reports to ICAS.

Nearly a year after the June 1971 ICAS report we interviewed officials from several of the lead agencies and were advised that, with one exception, no plans had yet been made concerning coordinating committees. Consequently, no action plans, multiagency participation, or coordination of projects had been developed. The one exception, the National Hail Research Experiment, a project for which NSF was the lead agency, needed no further plans since it had an operating committee before the ICAS report was issued.

FIGURE 2

PROJECTS AND RECOMMENDED INTERAGENCY
PARTICIPANTS IN THE ICAS NATIONAL
PROGRAM FOR ACCELERATING PROGRESS
IN WEATHER MODIFICATION

| Project | Lead Agency | Other Federal participants | | | | | | | | | |
|--|---|----------------------------|--------------------------|----------|---------|-------------------------------|----------|---|-----------------------------|----------------|---|
| | | Agriculture | Atomic Energy Commission | Commerce | Defense | Housing and Urban Development | Interior | National Aeronautics & Space Administration | National Science Foundation | Transportation | |
| Colorado River Basin Pilot Project | Interior, Bureau of Reclamation | X | X | X | | | | | | X | X |
| National Hurricane Modification Project | Commerce, National Oceanic & Atmospheric Administration | | X | X | X | X | X | X | X | X | X |
| National Project on Lightning Suppression | Agriculture, Forest Service | | | X | X | | X | X | X | X | X |
| National Project on Precipitation Augmentation from Cumulus Clouds | Commerce, National Oceanic & Atmospheric Administration | X | X | X | | | X | | | X | |
| National Hail Research Experiment | National Science Foundation | X | X | X | X | | X | X | | X | X |
| National Great Lakes Project | Commerce, National Oceanic & Atmospheric Administration | X | | X | | | X | | | X | |
| National Fog Modification Project | Transportation, Federal Aviation Administration | X | X | X | X | | X | | | X | X |

ICAS compiled the first progress reports in January 1973. Our review of these reports showed the following:

- The National Hurricane Modification Project was continuing with the Department of Defense and NOAA, although the ICAS report suggested a total of seven participating Federal agencies. The progress report noted that Defense had informed NOAA that, for fiscal year 1974 and beyond, it could support the project only as operational missions permitted. Since Defense plans included no budgeted funds for support, NOAA will be required to reimburse Defense (estimated at over \$1 million in fiscal year 1974) for any costs incurred over those required for operational missions. The general outlook for accelerating progress appeared poor. (See app. III for additional NOAA comments.)
- The National Lightning Suppression Project continued to be carried out by the Department of Agriculture's Forest Service, although the ICAS report suggested six additional participants. No formal coordination committee had been established, nor had the Forest Service received funding to support the planning activities assigned. The progress report stated that the major problem was the amount of funds the lead agency received for the proper discharge of responsibilities assigned. No new funding was received in fiscal year 1973, although a major funding increment will be required to validate results of field experiments carried out in the mid-1960s.
- The ICAS report suggested participation of five other agencies in NOAA's National Project on Precipitation Augmentation from Cumulus Clouds. The progress report stated, however, that the project needed no formal interagency coordination since it had been solely an NOAA project.
- The National Fog Modification Project had not established a Project Coordinating Committee or set up a Project Action Plan. The National Great Lakes Snow Redistribution Project progress report stated formal interagency coordination has been unnecessary as only NOAA and non-Federal agencies have been involved. The National Colorado River Basin Pilot Project plans were reviewed in a 1969 conference, but a continuing project coordinating committee had not yet been formed.

In April 1974 the Executive Secretary for ICAS said that, except for the changes discussed below, the degree of interagency participation in the national lead agency projects had not changed since the January 1973 progress reports.

The Department of Agriculture representative to ICAS advised the Chairman, ICAS, on September 11, 1973, that it was withdrawing as lead agency for the National Lightning Suppression Project because it had not received enough funds to exercise the leadership responsibility. The

Director, Environmental Modification Office, NOAA, advised us in April 1974 that the National Great Lakes Snow Redistribution Project was terminated in fiscal year 1973 because anticipated benefits were not being realized, desirable weather to conduct the project did not develop, and the project was not considered as a high priority.

ICAS apparently has had little or no impact in increasing coordination and accelerating progress in weather modification research and there has been little change in the way projects have been carried out.

PROBLEMS IN COORDINATING A NATIONAL PROGRAM-- NATIONAL HAIL RESEARCH EXPERIMENT

Since the Experiment was essentially organized to meet the objectives of a well coordinated lead agency project, we examined planning documents and agency participation in accomplishing the overall goals. This project was based on a plan prepared for NSF by the National Center for Atmospheric Research in Boulder, Colorado, operating under NSF sponsorship.

The Experiment which started in the summer of 1972, will be conducted in northeast Colorado over a 5-year period. The plan of operation involves the use of instrumented aircraft, specially designed radars, and other similar instrumentation. Storms will be monitored and those that show evidence of hail will be seeded randomly. The effect of seeding will be observed and related to mathematical models which have been proposed to explain hailstorm behavior. It is expected that these observations will provide the data for developing a realistic model which can be used to forecast hail and indicate how to suppress the growth of large hailstones.

ICAS recognized that such an experiment was too big for a single organization and that the effort should be a collaborative one. Therefore, it recommended NSF coordinate the expertise in various areas of hail research from universities, government agencies, and private sources. NSF authorized the National Center for Atmospheric Research for this management responsibility. The total cost to NSF was about \$16.5 million.

The Experiment's program plan for 1972 to 1976 and related planning documents set out equipment and services required and planned to be provided by the National Center, universities and private research groups, and the five Federal agencies designated to participate with the National Center (the Departments of Agriculture, Commerce, Transportation, and Defense--Army, Navy, and Air Force--and the Atomic Energy Commission). The plans proposed that the activities of the universities and private research groups would be funded through the National Center's hail project office with NSF funds. Federal agencies' participation would be largely self-supporting.

Even though the Experiment was well planned, requiring extensive interagency participation, we found, in comparing the planned efforts

with the actual efforts that, for the most part, agencies could not and did not meet all their obligations.

Department of Agriculture

Plans called for contributions by Agriculture in the assessment of crop damage from hail, and economic effects of hail suppression.

An Agriculture representative informed Experiment officials that Agriculture intended to assess crop damage from hail but that there were no funds to study the economic effects of hail suppression. NSF subsequently furnished funds to Agriculture to carry out this study.

The Experiment's plan noted that, because electrical forces in the atmosphere influence precipitation formation, it was imperative that a scientist with experience in field research be appointed full time to direct and coordinate electrical studies. Although the Forest Service lightning suppression group had experience in lightning measurement and evaluation and had indicated a willingness to furnish such services, the Forest Service subsequently stated:

"* * * our first obligation, the study of forest fires and the consideration of the needs of forest managers, is so great that we cannot accept with clear conscience the attractive offer to actively participate * * *."

Department of Commerce, NOAA

Initial plans called for NOAA to furnish aircraft and radars and establish and maintain a ground network of precipitation gauges, each essential in carrying out the project's objectives.

Aircraft

The plans called for use of three NOAA aircraft--a WB-57 and two DC-6's--for each summer during the 5-year period. The aircraft were to be used for observing the motion, temperature, and humidity fields environmental to the storms. However, during the field testing in 1971, the NOAA Administrator noted that, due to conflicts with other programs and limited funding, only one DC-6 could be made available at that time and that NOAA was reluctant to promise any improvement for 1972 and beyond until the funding and other requirements for aircraft were known.

Radars

Plans called for two 3-cm Doppler radars to be furnished to augment aircraft measurements of air motion below the cloud base. The only feasible means for obtaining this data was the dual Doppler radar system developed at NOAA. However, an Experiment official said both units had been committed to use by a NOAA laboratory on other programs and would probably not be available for the Experiment.

Ground network

NOAA initially agreed to supply the survey teams necessary to maintain and read the ground network stations. However, this could be accomplished only through NSF financial support. For the 1972 program NOAA submitted a proposal to NSF for about \$100,000 to fund this work. Since NSF had planned to give only about \$50,000, NSF had to cancel certain other items in the program plans.

Department of Defense

Helicopters

The Army was to provide two helicopters to maintain the extensive ground networks and collect hail samples. However, none were furnished. An Experiment official told us that the Army offered one helicopter for use during the 1972 operation but it was turned down because funding would have been too expensive.

Radiosonde stations

The plans called for four radiosonde stations to obtain data on temperature, humidity, and winds at frequent intervals in the atmosphere of the experimental area during the development and life of the storms. The Army and Air Force were to provide personnel and equipment necessary to man two stations each. However, because of a severe reduction in personnel, the Army was unable to support the 1972 operation. The Air Force subsequently furnished support for all the stations but advised officials that it was also experiencing personnel reductions which would likely eliminate its capability to support the program in 1973 and beyond.

Atomic Energy Commission

The Commission planned to conduct tracer studies and hailstone measurements, but its participation was conditional upon the availability of future funds. NSF funded the tracer studies, which were conducted during the 1972 summer project. The Experiment's Acting Deputy Director told us the Commission requested funding from the National Center for the 1973 summer project but, because the National Center did not have adequate funds, the tracer studies were not conducted.

Department of Transportation

The plans called for Transportation to provide flight control personnel. Three air traffic controllers participated in the 1972 field project.

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In most of the cases noted above, the Experiment's Director advised NSF of the problems in participation and funding. The ICAS chairman was asked to get firm commitments from respective departments and agencies. In nearly every case, the agencies cited personnel reductions, limited funding, or mission-oriented research as the primary reason for nonparticipation. The Deputy Director, citing NOAA as an example, stated that planning is very difficult because it is never known until the last minute whether agencies can participate during each project year. (See pages 27 and 28 for additional comments on the Experiment.)

CHAPTER 3
CONCLUSIONS, AGENCY COMMENTS,
AND RECOMMENDATIONS

CONCLUSIONS

A national program in weather modification research is necessary to effectively control activities of the agencies involved. Although this need was recognized as early as 1966, the organizations established to coordinate these activities have not developed and implemented an effective overall national program. Although coordinating groups have tried to develop national programs, their implementation has not been successful. The present fragmentation of research efforts has made it extremely difficult for agencies to conduct effective field research which, in the case of weather modification, must precede operational activities.

If and when the results achieved from the weather modification research programs are ready to be applied on an operational basis, the various mission-oriented agencies will be responsible for making decisions. Procedures will be needed for insuring that operational programs conform to the public interest in every way--scientifically, socially, ecologically, economically, and legally. Before programs become operational agencies must insure that all effects of the operation are known within reasonable limits, all affected parties are represented in the decisionmaking process, and adequate provision is made for liability in case of damages. The state of the art with the present fragmented and subcritical programs spread throughout many agencies, each with its own mission-oriented research effort, has not progressed sufficiently to achieve these requirements.

AGENCY COMMENTS AND OUR EVALUATION

In making our findings available to several Federal agencies for review and comment, we suggested that OMB develop and maintain (1) a national weather modification research program with goals, objectives, priorities, and milestones, (2) appropriate plans to define responsibilities of all Federal agencies involved in weather modification research, and (3) plans to allocate resources to the national program elements.

While most agency comments acknowledged the administrative and management problems stated in our report, they were not consistent in agreeing on what actions, if any, should be taken to resolve the problems. Their specific agency comments on our findings and recommendations follow.

Consolidation of Research EffortsCommerce

The Department agreed with our conclusions and recommendations and commented that a proposal to establish a Department of Energy and Natural Resources would bring together many of the widely scattered elements in Federal weather modification programs.

Transportation

"* * *We believe some consolidation of weather modification is desirable, but would not necessarily conclude that all such research should be concentrated, or that a lead agency approach for all generic weather modification is preferable."

OMB

"We view weather modification research not as a panacea but as an option, a possible means not as an end. * * *We believe the mission agencies rather than a single centralized agency should conduct the type of research activities they believe most suited to the national problems faced by them. Consequently, we believe that some consolidation of weather modification is desirable* * *the DENR [Department of Energy and Natural Resources] proposal will accomplish the appropriate degree of consolidation."

GAO evaluation

Regarding the consolidation of weather modification research activities, Senate bill 2135 and House bill 9090 would transfer to the proposed Department of Energy and Natural Resources the programs of the Bureau of Reclamation, Department of the Interior; NOAA; and the Forest Service, Department of Agriculture.

While the proposed reorganization plan should provide the opportunity for the new Department to more effectively manage the research efforts of these three agencies, we believe the problems in administration and management, such as funding competition and lack of interagency cooperation in participating projects, would continue because a national weather modification program would not exist.

Senate bill 2135 and House bill 9090 were introduced on July 10, 1973, and on June 29, 1973, respectively, and referred to their Committees on Government Operations. As of July 1, 1974, the bills were with the Committees and were not under active consideration.

A national program for
weather modification

Agriculture

"* * *The difficulty with developing any overall national program direction is that the Federal agencies involved in weather modification have specific mission requirements that dictate particular research and development needs for weather modification technology. Agencies request their * * * funds, and Congress appropriates the money, on the basis that a specific mission requirement will be satisfied * * *. I would not wish to defend a budget request on the basis that it enabled us to participate in a national weather modification program. * * *"

Defense

"* * *Such a 'national program' could place an executive department or agency in the untenable position of being directed to allocate its resources to national program requirements. * * *executive departments can ill afford to have their programs directed by, or priorities established by, another government agency."

GAO evaluation

In our opinion, these comments highlight a major problem with the current fragmented Federal organization for weather modification research and the national projects established by ICAS--namely, weather modification activities must compete with an agency's mission priorities for funding and do not have the opportunity to compete against one another to establish national weather modification research priorities.

We would not expect that developing and implementing a national program would force agencies to carry out research totally unrelated to their missions. The agency designated to administer the national program should coordinate its funding requests for weather modification research with budget requests of other agencies and, when appropriate, could allocate its resources to other agencies for performing research.

In those instances where a major aspect of an agency's mission-related research is not consonant with the objectives and priorities of the national program, the agency would have the opportunity to justify its particular needs through OMB's budget process. We think that in most situations the need to do so would probably not happen since all agencies involved in weather modification would be involved with OMB in establishing the objectives and priorities of the national program.

Lead agency responsibilityDefense, Interior, and OMB

These agencies commented that, because weather modification research projects are significantly different in nature and technology, it would be difficult to proceed under the direction of a single agency.

For example, Interior said equipment and techniques, atmospheric data and models, decisionmaking processes, types of people and environment involved, and basic hypotheses are significantly different. In essence, this position supported ICAS' recommendation to continue with lead agencies for specific types of weather modification research.

GAO evaluation

ICAS recognized that an interdisciplinary multiagency approach would be necessary to accelerate progress in each project. As stated earlier, the designated lead agency has not always received agencies' participation and, in general, the national research projects showed little progress. One reason for the lack of multiagency participation in the projects is that weather modification research is not a high priority in an agency's mission. In our opinion, a national lead agency authorized to establish priorities and allocate resources would resolve the administration and management problems of national lead agency projects.

Regarding the differences in nature and technology of weather modification research projects, we assume a national lead agency would use the available expertise within Federal agencies in effectively managing a national program.

Status of weather modification researchNSF and OMB

These agencies commented that present weather modification activities are not sufficiently supported by scientific understanding and that a national weather modification research program would put undue emphasis on a technology that is mainly in the research stage.

GAO evaluation

We agree that weather modification activities should be supported by sound scientific understanding. However, a national program that would accelerate progress in weather modification research is not inconsistent with attaining greater knowledge.

NAS, in its 1973 report, "Weather & Climate Modification Problems and Progress," stated:

"* * *we still do not know, with a satisfactory degree of confidence, the precise meteorological conditions under

which it is possible to increase, decrease, or redistribute precipitation, what measures might be taken to mitigate the damaging effects of severe storms, or to what extent man is changing the climate of his cities and of his planet. This situation is likely to persist unless stronger and more unified federal programs are developed."

Weather modification coordination and priorities

Agriculture, Defense, and OMB

Defense and OMB commented that weather modification research is well coordinated by ICAS. It meets monthly and provides members and observers the opportunity to exchange information. Agriculture noted several examples of interagency cooperation in the exchange of computer models and equipment.

GAO evaluation

We agree that ICAS provides an excellent opportunity to meet and exchange information. However, lacking any type of directive authority, its efforts to coordinate weather modification research programs through interagency participation have had little success. For example, the ICAS recommendation to create a coordination committee for each of the national projects has, with one exception, never been implemented. The exception, the National Hail Research Experiment, already had a coordination committee. Effective coordination with positive results is very difficult to attain by only meeting and exchanging information. It also involves, as ICAS recommended, active interagency participation in the designated national projects.

Agriculture, Defense, Interior, and OMB

Agriculture further stated that its lightning research program had been underfunded for some time and that its funding was totally inadequate to discharge the leadership role suggested by ICAS. The major problem cited was the competition of funding priorities of weather modification research with other mission-oriented research.

Defense stated that its commitments to support cooperative pilot projects have always been contingent on the availability of resources. Resources and programs are mission-oriented, and funding is justified on that basis. It contended that, in allocating resources for cooperative national programs, it was evident such allocation had competed successfully with that of other Defense internal programs.

Interior stated that less than full interagency participation in ICAS efforts has been due primarily to financial and scientific reasons rather than a lack of organization or cooperation. It contended that implementation of ICAS recommendations primarily depends on adequate funding.

OMB stated that, to imply that project budgets are subcritical or to support citations to that effect, is a rather narrow view. It noted

that, where project budgets were reduced to accommodate other goals, weather modification research could be considered a lower priority.

GAO evaluation

The designation of lead and participating agencies on the national projects recommended by ICAS was a recognition that current programs were subcritical. The ICAS report noted that current projects consisted of small and occasionally independent groups and concluded that progress could be accelerated under a multiagency approach. Since both Agriculture and Commerce have labeled their own programs as subcritical we do not consider our support of these statements as a narrow view.

While Defense contends it has been successful in allocating resources to national programs, our report shows it limited its participation in the Experiment and withdrew support on the National Hurricane Modification Project.

In our opinion it is unrealistic to assume that adequate funding will solve the current problems in implementing a national program. Requirements still need to be recognized, priorities established, and resources allocated to the most beneficial programs.

Relative priority of weather modification

NSF

NSF said it was prepared to believe that developing weather modification is a valuable national asset; however, neither the report nor any of the studies cited were able to establish clearly the priority of this national need.

GAO evaluation

Our report and the other studies were not intended to assess the weather modification research priority status as it relates to other societal needs. However, we would expect that such assessment would be a major objective in developing a national program so that its priority could be realistically evaluated among competing national needs.

National Hail Research Experiment

NSF

NSF stated that the Experiment has achieved excellent progress. The project director reported cooperation among participating organizations. Many items discussed in the report were minor and have been overcome. The only impediment has been the lack of sufficient, suitable conditions which produce hail clouds. NSF commented that the report overlooked the basic fundamental mechanism for establishing coordination in multiagency programs--to centralize the flow of funds. Had NSF been given the funds to subcontract for essential

services to other agencies, coordination problems would not have occurred.

GAO evaluation

We subsequently contacted the Acting Deputy Director of the Experiment to determine the status of and participation of agencies in the most recent operating season (summer 1973) and found the following.

NOAA was able to furnish the Doppler radars for the first time, but could not furnish any aircraft in that period or for the remainder of the Experiment. Also, by mutual agreement, NOAA no longer participates in the operation of the ground network. It has requested funding from the Experiment for its Doppler radar participation in the 1974 season. Because of its importance to the program, the Experiment expects to fund this effort.

The Naval Electronics Laboratory Center took on the electrical studies in 1972 after Agriculture withdrew but advised that, for 1973, it could only fund projects that were directly oriented to purposes of the fleet. However, there would be no problem if outside support from the Experiment was obtained. The Experiment's Acting Deputy Director advised us that the Experiment was not able to furnish funding for 1973 and it is unlikely it could in future years.

Because of the foregoing, important segments of research were lost for 1973 and probably for the remainder of the Experiment. Initial plans designated NOAA's aircraft as critical for midlevel cloud exterior measurements. Also, the initial plans concluded that electrical effects were such an important part of the Experiment that it was imperative to make this a part of the program during the duration of the project.

In our opinion each operational season has had, and probably will continue to have, problems with commitments from participating agencies unless the organizational structure is changed. We agree that centralized funding would tend to eliminate problems and believe that, if a lead agency were managing a national program, such funding could be used.

- - - -

The agency comments, in our opinion, further support the need for a national program by their acknowledgment of limited scientific understanding of weather modification activities and the recognition that progress is being hampered by the current fragmented Federal organization structure. Although some agencies implied or stated that additional funding would accelerate progress, we believe that a national program would more effectively do so by clearly establishing national priorities and making more beneficial use of existing resources.

RECOMMENDATIONS

GAO recommends that OMB should, in cooperation with the Federal departments and agencies involved in weather modification research:

- Develop a national program with goals, objectives, priorities, and milestones, designating one of the agencies, which would have a major program responsibility, to administer and maintain the national program.
- Develop a plan to define and reassign, if appropriate, the responsibilities of Federal departments and agencies providing support or conducting weather modification research.
- Develop a plan to allocate resources to the national program elements.

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WEATHER MODIFICATION PROGRAMS

AND FEDERAL PARTICIPANTS IN FISCAL YEAR 1974

Most weather modification field research experiments are based on:

- Development and use of seeding material, such as silver iodide which is the most common.
- Acquisition and use of delivery systems to place the seeding material into the cloud.
- Development and use of measuring equipment and devices to determine the physical characteristics (temperature, pressure, humidity, wind velocity, etc.) in the cloud and atmosphere before, during, and after seeding.
- Evaluation of data over a period of several seedings or against a predetermined model to determine success or results.

PRECIPITATION MODIFICATION

The general purpose of precipitation modification research is to study and develop techniques to manage and control rain or snow. Federal support for this research has been provided principally by the Interior, Commerce, and NSF. Planned expenditures for fiscal year 1974 for these three agencies total \$3,690,000.

Department of the Interior--\$2,400,000

Interior has supported precipitation modification research since 1962 under its Project Skywater which is administered by Interior's Bureau of Reclamation. Project Skywater's principal objective is to learn how to manage precipitation through cloud-seeding technology to help meet the growing water needs in the western mountains and the high plains regions of the United States.

Initially such seeding involved winter storm clouds only. On the basis of field experiments on winter-storm cloud seeding in the western United States, Interior has estimated that seasonal snowfall there can be increased by 10 to 30 percent. In fiscal year 1974, 11 such field experiments will be concluded for the purpose of performing a comprehensive analysis of current research before continuing future efforts.

Experiments involving seeding summer cumulus clouds under Project Skywater started in 1965 in various western states. During

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fiscal year 1974 Interior plans to begin the High Plains Cooperative Program. This major program is intended to last 5 to 7 years and will require joint funding by local and State groups and other agencies. Program goals are to resolve remaining uncertainties in summer cumulus cloud seeding and to establish by 1980 a working technology capable of producing additional rain in the semiarid high plains region.

Fiscal year 1974 plans call for continuing a joint effort with the California Department of Water Resources for planning and ecological studies in the Central Sierra Mountains of California and Nevada to aid in evaluating the effects of cloud-seeding activities.

Department of Commerce--\$840,000

Commerce, through NOAA, supports research aimed at increasing rainfall from tropical cumulus clouds. Experimental seedings were conducted initially over the Caribbean Sea in 1963 and 1965. Since 1968 such experiments have been conducted over Florida.

Experiments by NOAA's Experimental Meteorology Laboratory in seeding cumulus clouds in Southern Florida show a threefold increase in precipitation. Other experiments indicate the possibility of increased precipitation by stimulating the merger of two cumulus cloud systems. The ultimate objective is to achieve technology transfer of drought relief methods to the State of Florida and other regions with similar meteorological conditions.

Other activities involve the development of cloud models, including cloud merger models and feasibility studies of precipitation measurement by remote sensing techniques from existing satellites.

NSF--\$450,000

NSF's research is focused on improving knowledge of precipitation mechanisms that are modified by artificial nucleation. Efforts will center on the scientific interpretation of the results of other agencies' seeding programs. Emphasis will be placed on nucleation mechanisms, nucleation efficiency, downwind effects, and the overall microphysical and dynamic mechanisms involved in cloud-seeding operations.

HAIL SUPPRESSION

The purpose of hail suppression research is to develop techniques to eliminate or reduce the size of hailstones to reduce the damage potential.

ICAS recognized by 1969 that a large and long-term field experiment was needed to achieve results in this area. It also recognized that such an undertaking required more resources than would be

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available to a single research group. It recommended establishing a centrally directed, collaborative effort of the groups involved in hail suppression research.

In 1971 the many organizations conducting hailstorm research were organized under the Experiment, a 5-year research program in northeastern Colorado. Its aims are to understand the physics of severe convective storms, assess the feasibility of suppressing hail damage to crops, and examine the effect on society of conducting an operational hail suppression program if an operational program proves to be possible.

The Experiment is directed by the National Center for Atmospheric Research, in Boulder, Colorado, with NSF providing substantially all of the funding. For fiscal year 1974, NSF estimates about \$3,250,000 will be provided to the Center for conducting the third field year of the Experiment. The Experiment will continue its program to obtain more adequate information on the dynamics and microphysics of severe convective storms capable of generating damaging size hailstones. Its objective is to develop a mathematical model which can forecast hail growth conditions and indicate the most effective means for suppressing large hailstone growth.

INADVERTENT MODIFICATION

This research involves monitoring of atmospheric constituents and studies of their modifying influences on the weather. Federal support for inadvertent modification research is provided by Transportation, Commerce, and NSF. Planned expenditures for fiscal year 1974 total \$2,912,000.

Department of Transportation--\$1,304,000

Transportation is continuing the Climatic Impact Assessment Program to assess the environmental and meteorological effects of the projected world high-altitude aircraft fleet, including subsonic and supersonic vehicles. The program is considering the interactions between engine emissions exhausted into the upper atmosphere, the natural composition of the stratosphere, and the dynamic processes of the atmosphere. Transportation is also conducting studies to evaluate and develop transportation system air pollution models to describe the diffusion, transport, and chemical dynamics of air pollutants near transportation-related sources.

Department of Commerce--\$908,000

NOAA's program called Global Monitoring of Climatic Change has the objectives of establishing a comprehensive air quality baseline monitoring network and being able to predict changes in climate resulting from man's activities. A baseline station at Pt. Barrow, Alaska, is planned for full operation in fiscal year 1974. Preliminary

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monitoring is being done at American Samoa in cooperation with the National Center for Atmospheric Research.

During fiscal year 1974 limited solar radiation measurements are planned at Antarctica and systems will be designed for new trace-elements sampling along with oceanographic measurements of temperature and salinity for use off the coast of Hawaii.

NSF--\$700,000

Inadvertent weather modification research continues to focus on project Metropolitan Meteorological Experiment in St. Louis which is aimed at assessing urban impact on local weather patterns and the identification of the responsible mechanisms. NSF will continue to support data-gathering elements required for Metropolitan Meteorological Experiment objectives in the St. Louis area, such as the Illinois State Water Survey, University of Chicago, and Stanford Research Institute.

The possibility that urban and industrial pollution may tend to deepen or prolong drought during times of atmospheric water deficiencies will also be explored.

FOG AND CLOUD MODIFICATION

The principal objective of research in this area is to study and develop methods to dissipate cold (under 0 degree Centigrade) and warm (over 0 degree Centigrade) fogs. Four agencies are carrying on research in this modification area with fiscal year 1974 planned expenditures totaling \$2,477,000.

Department of Defense--\$1,534,000

Defense's major point of attack is concentrated on warm fog due to its frequent effects on almost all military operations whether conducted in the air, on land, or at sea.

The Navy is intensifying its warm maritime fog investigations. The Air Force's plans for warm fog dispersal are concentrated on the heated plume technique which includes redesign of burners, studying the use of propane and natural gas, evaluating the first year's operational results of the French installation at Orly, and preparing for advanced development of a warm fog dissipation installation at Travis Air Force Base, California.

The Army is studying the warm fog life cycle to determine how it can be altered by helicopter downwash, hygroscopic materials, and heat.

Dissipation of cold fogs was performed as an operational program during the winter of 1970-71 at a number of air bases. These efforts

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resulted in the successful completion of more than 500 takeoffs and landings during fog conditions which would formerly have caused suspension or curtailment of air operations.

NSF--\$800,000

NSF's research in this area is related to the application of basic knowledge to explaining and predicting warm cloud precipitation processes and the role of ice nucleation in cold cloud systems. Emphasis is to be placed on more accurate detection and measurement of ice-forming nuclei involved in the atmospheric processes and the development of new nucleating materials using more inexpensive and available materials compatible with the balance of nature.

Department of Transportation--\$93,000

The Federal Aviation Administration will continue its research to:

- Develop an economical operational ground based fog dispersal system.
- Test the efficiency of biodegradable glycerine for fog dispersal and develop treatment techniques.
- Monitor the development and operation of both foreign and U.S. fog dispersal systems and exchange information in this area.

National Aeronautics and
Space Administration--\$50,000

The agency supports fog modification studies for aeronautical safety applications. The objective is to study the life cycle and micro-physical properties of fog in order to develop techniques to dissipate fog over and around airports and heliports.

HURRICANE AND SEVERE
STORM MODIFICATIONS

The purpose of hurricane modification research is to determine the extent to which hurricanes can be beneficially modified. Commerce has conducted hurricane research since 1956 and between 1962 and 1972 under Project Stormfury, a joint project with Defense.

Field experiments made on four hurricanes--all on the Atlantic Coast--between 1961 and 1971 indicated, in one case, that the destructive effects may be decreased. According to Commerce, a decrease in the wind velocity was noted after seeding Hurricane Debbie in 1969, but the level of the decrease was within the range of natural variability of hurricane winds and the results were therefore inconclusive.

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On the basis of the scarcity of storms acceptable for seeding experiments in the Atlantic Ocean, the need for newer aircraft, and Defense's decision to participate only on a reimbursable basis, NOAA discontinued field experiments of Project Stormfury until safe, well instrumented aircraft are available for operations in the Pacific Ocean where storms acceptable for experimentation are more frequent. (See page 43 for additional comments on Project Stormfury.)

Meanwhile other research activities will continue. These include the possibility of moderating or modifying other types of severe storms, such as thunderstorms, tornadoes, and east coast storms.

Planned expenditures for fiscal year 1974 amount to \$1,548,000.

LIGHTNING MODIFICATION

The purpose of lightning modification research is to determine the basic characteristics of fire-setting lightning storms and develop techniques to suppress or modify lightning discharges. Lightning research efforts are supported by Agriculture, Defense, and NSF.

Planned expenditures for fiscal year 1974 total \$653,000.

NSF--\$300,000

Most of NSF's research in the modification of cloud electricity is directed toward a study of the basic concepts, which relate cloud electricity to precipitation, and the possibility of inducing or augmenting rainfall by electrical charge modification. Observations and experiments are conducted from a mountain-top observatory and an extensive network of ground sensors and radars in the vicinity of the New Mexico Institute of Mining and Technology in New Mexico.

Department of Agriculture--\$293,000

Agriculture's Forest Service lightning modification research was started in 1953. Designated as Project Skyfire, it is the United States' oldest continuously performed weather modification project. Objectives of the project, which is located at the Northern Forest Fire Laboratory, Missoula, Montana, is to test a hypothesis that the seeding of northern Rocky Mountain thunderstorms with silver iodide can significantly reduce cloud-to-ground lightning strokes which are responsible for the majority of forest fires in the intermountain West.

A major effort of the fiscal year 1974 program will be planning for full cooperation and participation in the lightning abatement experiment to be carried out by Interior's Bureau of Land Management over interior Alaska.

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Department of Defense--\$60,000

The Air Force will investigate electrical charges of cumulus clouds to determine when and where they are most easily susceptible to discharging.

OTHER

Other costs represent research efforts related to mathematical modeling; social, economic, legal, and ecological studies; and support and services. Planned expenditures for fiscal year 1974 total \$2,887,000.

NSF--\$1,100,000

Mathematical modeling research in cloud dynamics and micro-physics is conducted in universities and at the National Center for Atmospheric Research to determine the mechanisms in severe storms which cause the formation of hail, severe winds, and lightning.

In most instances, actual experimental data from real storms is not available to critically test the validity of the devised models. Field observations made during the Experiment and additional laboratory data on microphysical and dynamic features of clouds will be used to refine the models and test their accuracy in forecasting the results of modification.

Studies involving the legal, social, and ecological aspects of weather modification will be continued at universities and nonprofit institutes. The social, legal, and economic studies of hail suppression will be incorporated into the Experiment's progress reports and will provide guidance to Federal, State, or municipal groups who plan to engage in hail suppression on an operational basis.

Department of Commerce--\$937,000

The NOAA Research Flight Facility provides aircraft support, including seeding and airborne measurements, to all NOAA weather modification activities.

Department of the Interior--\$850,000

General program support includes the continuation of the series of Skywater Conferences--seven have been held on specific problems--and field support, including snow surveys, steam gauging, and silver analyses.

Scientific and equipment assistance with access to the Bureau of Reclamation's Environmental Data Network will be provided to local- and State-sponsored projects.

Three principal ecological studies--San Juan Mountains of Colorado, Great Plains, and Sierra Mountains of California--will continue in 1974.

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Washington, D.C. 20250

4400-

AUG 23 1973

Mr. Richard J. Woods, AD
Resources and Economics Development Division
United States General Accounting Office
Washington, D.C. 20548



Dear Mr. Woods:

We appreciate the opportunity to review and comment on the draft of your report to Congress entitled "The Need for a National Program in Weather Modification Research." In general, your report is a fair and accurate description of the past and present Federal activities in weather modification research. We noted, however, that your findings tended to rely heavily on the series of past studies and reports by various groups that were cited in your report. Most of these implied or concluded that weather modification research in the Federal Government was poorly coordinated, fragmented, and underfunded. In each instance the conclusions of the study were that a "national program" is needed and that more money ought to be spent in weather modification research.

None of the reports, including your own GAO study, appears to have identified any particular fault--lack of progress, for example--which could be traced directly to any of the defects which the report finds. Your report should provide more concrete evidence to substantiate the charges that it makes. What specific deficiency did you find in the output of the Nation's weather modification research program? Was the output too small; was it trivial or lacking in scientific merit? To label a program with terms such as "uncoordinated, fragmented, sub-critical," without citing meaningful concrete evidence for these deficiencies raises questions regarding the validity of the findings.

Speaking for the Forest Service, I can agree that our lightning research program has for some time been underfunded in terms of the opportunities which our scientists see to advance the research at a faster pace and to validate the developed technology in comprehensive field experiments. Our funding is of course totally inadequate to discharge the leadership role in the National Lightning Suppression Project assigned to us by ICAS report 15-A. However, I cannot agree that our program is poorly coordinated as I understand the meaning of that term. Incidentally, there appears to be a tendency in your report to assign to "coordination"

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a meaning which I associate with the words "integration, central control and direction." Our lightning research has been directed at meeting our responsibility for protecting forests from fire. We have not attempted to integrate our research with lightning research programs of other agencies (NOAA, NASA, or DoD, for example) whose missions and concerns regarding lightning phenomena are quite different from our own. We do collaborate and cooperate with sister agencies in weather modification research and experiments where it is of mutual benefit to do so. Recent examples of this cooperation are:

The Forest Service lightning research personnel joined with the Department of the Interior scientists in an experiment to evaluate the efficacy of cloud seeding in suppressing lightning fires over interior Alaska, from June to August, 1973.

Project Skyfire has made available its silver iodide generators to the Bureau of Reclamation for use in the Bureau's Skywater project.

Project Skywater has provided Skyfire with computer models for use in simulating cloud behavior and testing cloud seeding effects.

The Naval Weapons Center made available to Project Skyfire silver iodide flares for use in its cloud seeding work.

These are but a few examples of the interagency cooperation that has existed from time to time in the area of lightning research. I am told that similar collaboration exists between other Federal agencies involved in weather modification research.

Your report makes much of the failure of agencies to actively participate in the field program of the National Hail Research Experiment (NHRE). I agree that it is regrettable that the Department of Agriculture and others were not able to participate in NHRE, but in our case, we had to decide whether the Forest Service weather modification scientists would conduct the electrical measurements required by the NHRE program in the experimental area in northeastern Colorado or go to Alaska to work with the Bureau of Land Management in its program for suppressing fire-starting lightning storms over Alaska wildlands. We concluded that our work in Alaska was more important to the mission of the Forest Service and directed that Skyfire undertake the Alaskan project in 1973. I feel that GAO could easily have criticized our doing otherwise.

In citing the lack of participation by some agencies in the National Hail Research Experiment, you have come across a real problem in

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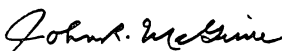
making your national program concept work. The difficulty with developing any overall national program direction is that the Federal agencies involved in weather modification have specific mission requirements that dictate particular research and development needs for weather modification technology. Agencies request their research and development funds, and Congress appropriates the money, on the basis that a specific agency mission requirement will be satisfied through the conduct of the proposed R&D. The Forest Service would not be able to present its budget requests before our congressional committees on any other basis. Certainly I would not wish to defend a budget request on the basis that it enabled us to participate in a national weather modification program. I doubt that many agency heads would be so inclined.

Our review of the ICAS record over the past 10 years indicates that that group has not been unmindful of the need to coordinate programs and has devoted a great deal of attention to weather modification research.

GAO note: Material has been deleted because of changes to the final report.

I have no basis for judgment on the adequacy of the Nation's overall weather modification research, or whether anything at all is wrong with the present program. In our research, the problem is one of funding priorities: Weather modification research in the Forest Service must compete for funds with research on such items as tree genetics, entomology, forest pathology and others. I am sure that other Federal agencies must make similar choices. It is not clear that the creation of a National program would relieve any of us of the need for making those difficult decisions on the allocation of research resources.

Sincerely,



JOHN R. MCGUIRE
Chief

APPENDIX III



UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

September 13, 1973

Mr. Donald C. Pullen
Assistant Director
General Government Division
U.S. General Accounting Office
441 G Street, N. W.
Washington, D. C. 20548

Dear Mr. Pullen:

This is in reply to your letter of August 8, 1973, requesting comments on the draft report on the review of weather modification research programs being conducted by various Federal departments and agencies.

We have reviewed the comments of the National Oceanic and Atmospheric Administration and believe they are appropriately responsive to the matters discussed in the draft report.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "H. B. Turner", written over a horizontal line.

Henry B. Turner
Assistant Secretary
for Administration

Enclosure

APPENDIX III

I. SUMMARY

In general, the Department of Commerce agrees with the conclusions and most of the recommendations contained in the GAO Draft Report.

The Department of Commerce believes that the President's proposal to establish a Department of Energy and Natural Resources (S. 2135) will bring together many of the widely scattered elements in Federal weather modification programs, and substantially resolve the issues raised in the GAO Draft Report. The new Department, for example, will include the weather modification programs of the Forest Service (Department of Agriculture), the Bureau of Reclamation (Department of the Interior), and the National Oceanic and Atmospheric Administration. The opportunity will be provided for developing a well-formulated, single, strong, national program in this increasingly important field.

II. COMMENTS ON SPECIFIC RECOMMENDATIONS

[See GAO note, p. 39.]

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[See GAO note, p. 39.]

- C. A national program for weather modification research, with goals, objectives, priorities, and milestones, conforming to identified needs.

The Department of Commerce supports this recommendation with the understanding that OMB will draw heavily upon the efforts of existing interagency coordination mechanisms to gain access to technical expertise and results achieved thus far in defining a national program.

- D. A plan to define and reassign, if appropriate, the responsibilities of all Federal agencies that provide support or conduct weather modification research.

The Department of Commerce believes that this plan is an essential part of the national program discussed in the previous recommendation. Weather modification technology and supporting research should remain available for use by all agencies of the Federal government in the discharge of their mission responsibilities.

- E. A plan to allocate resources to the national program elements.

The Department of Commerce supports this recommendation in the context of implementing a national program in weather modification. Carried to extremes, however, this directed use of resources does limit the flexibility of agency management.

[See GAO note, p. 39.]

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GAO note: Page numbers referred to in these comments are those of our preliminary report, not this final report.

III. FURTHER COMMENTS

With reference to comments on pages 3 and 33 of the draft report concerning the National Hurricane Modification Project, NOAA has developed a program to modernize and instrument its Research Flight Facility aircraft in order to conduct the experimental field program. The technology to modify hurricanes must insure stringent safety standards, avoid endangering populated areas, and avoid reducing the essential, and substantial, contribution to annual water supplies these large tropical storms provide. The experimental field program necessary to verify our capability to produce predictable results, and to confirm the results to date, will require five modern turbo-prop aircraft capable of penetrating hurricanes and measuring accurately all meteorological parameters relevant to the program. NOAA developed a two-year plan to retire three out of the four aircraft which were obsolete, procure one new replacement aircraft, and install advanced airborne measurement systems in the two NOAA aircraft. A joint plan has been developed in which the Department of the Air Force will provide the use of three C-130 aircraft, and NOAA will procure and install the advanced instrumentation systems needed on these Air Force aircraft. NOAA will budget for the additional costs of operating Air Force and NOAA aircraft during the tropical storm season beginning in June 1976, designated Project STORMFURY-Pacific. The plan is based on operating the field experiment in the Pacific to take advantage of the larger number of occurrences of tropical storms in this area compared to the Atlantic-Gulf of Mexico area. By this plan, NOAA was able to obtain the aircraft support needed without the necessity of purchasing five new aircraft at a cost exceeding \$36 million. The OMB has given this planning effort firm support.

The necessity of developing the aircraft and airborne instrumentation support needed for Project STORMFURY caused a delay in the field program until June, 1976. During this period, the National Hurricane Research Laboratory will be engaged in improvement of models, participation in the Atlantic Tropical Experiment of the Global Atmospheric Research Program and evaluation of the basic hypotheses in terms of data on hand.

The Department of Commerce experience in developing and funding the National Hurricane Modification Program is indicative of the problems caused by weather modification research programs which are funded at levels below the initial mass needed for expeditious and cost effective completion of the program. The uncertainties of interdepartmental support have hampered the development of effective long-range plans. Delays were occasioned when the changing mission priorities and restriction of research goals led to the DOD withdrawal from joint sponsorship of Project STORMFURY and recommendation that NOAA assume the lead agency role. The requirements of the budget

APPENDIX III

cycle, instrumentation development cycle, and aircraft and instrumentation procurement cycles introduce further delays in this program. These long-lead time factors can be planned with minimum delays in the program when the critical mass for a successful program is available and continuity can be guaranteed. [See GAO note, p. 39.]

APPENDIX IV



DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

12 NOV 1973

Mr. R. W. Gutmann
Director
Procurement and Systems
Acquisition Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Gutmann:

This is in response to your letter of 10 August 1973 requesting DoD comments on the 31 July 1973 GAO Draft Report, "Need for a National Weather Modification Research Program."

The DoD research and development effort in weather modification is conducted because of two major defense interests: (1) protecting personnel and resources against weather hazards, thus improving our operational capabilities; and (2) guarding against technological surprise by increasing our understanding of the capabilities any potential adversary might possess in this area.

The GAO report concludes that a national program and a lead agency are needed "for the now fragmented federally-supported weather modification research activities." Such a "national program" could place an executive department or agency in the untenable position of being directed to allocate its resources to national program requirements. The DoD must retain the option to conduct RDT&E in those areas of atmospheric sciences, including weather modification, which offer the greatest potential contribution to solving problems associated with weapons systems and tactical and strategic operations. In the existing structure of our government, mission-oriented executive departments can ill afford to have their programs directed by, or priorities established by, another government agency.

The DoD has supported the Interdepartmental Committee for Atmospheric Sciences (ICAS) in recommending against a "national program" in weather modification. The Pilot Projects named in ICAS Report 15a constitute parts of programs which seek solutions to problems of national or near-national dimension. For example, the national problem is damage and destruction resulting from tropical storms: hurricane modification is but one approach to damage reduction; others include

APPENDIX IV

better construction methods, improved land usage, better warning services, effective disaster assistance plans, etc. In short, weather modification techniques represent possible but not unique solutions to national problems.

The GAO report makes strong reference to "ineffective coordination." Weather modification research is well coordinated by the ICAS, which meets monthly and provides members and observers the opportunity to exchange information in a timely manner. Further, ICAS just completed sponsoring the 15th annual interagency conference on weather modification, which provides project managers and scientists a forum for exchanging ideas, resolving problems, and the potential for planning joint efforts. The purpose of coordination is to achieve a minimum of duplication, reduce interference, promote mutual assistance, and provide the impetus for cooperative projects. The effectiveness of coordination should not be judged on such criteria as an apparent failure to inspire larger programs.

[See GAO note, p. 39.]

Weather modification research involves projects which are separate and distinct because of the very problem being attacked. Federal agencies, in conjunction with OMB, have recognized these differences and have decided to concentrate their respective efforts in specific areas most relevant to their individual mission requirements; Commerce

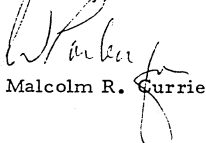
APPENDIX IV

in severe storms, Interior in precipitation, NSF in hail suppression, etc. Regarding duplication, there is invariably some overlap among the projects conducted because hailstorms, cumulus cloud development, and tropical storms do have some common meteorological characteristics. In basic research, some duplication is essential and does not constitute a significant problem. It should be recognized that the projects are significantly different to support having them conducted principally under the direction of a mutually agreed upon lead agency. Thus, we conclude that there are, in effect, recognized lead agencies for specific types of weather modification research, mission requirements and objectives having dictated who leads in what project.

The GAO report discusses the fact that support to weather modification projects by cooperating agencies has not always been forthcoming. DoD commitments to support cooperative pilot projects have always, of necessity, been contingent upon the availability of resources. DoD resources and programs are mission-oriented; funding for them is justified on that basis. In volunteering (allocating) DoD resources for support of cooperative "national" programs, it is evident that such allocation has competed successfully with other internal DoD programs; it must be recognized that this cannot always be the case due to stringent Congressional and budgetary constraints. One possible solution to the issue raised by the GAO is to identify an agency as the lead agency in a particular aspect of weather modification research, and then provide that agency the resources to conduct an adequate program. This means, for example, that the NSF in its conduct of the National Hail Research Experiment (NHRE), would have the means to reimburse other federal agencies for services rendered, or obtain the services from a contractor if mission requirements precluded other federal agency participation. A case in point in this regard is the Congressional designation of the Department of Transportation (DoT) as the lead agency in the conduct of the Climatic Impact Assessment Program (CIAP): CIAP is to assess by 1974, the impact of climatic changes on people, plants and animals, resulting from propulsion effluents of vehicles in the stratosphere, as projected to 1990; the DoT has been allocated by the Congress some \$25 million over 4 fiscal years to get this job done.

We appreciate the opportunity to comment on your draft report.

Sincerely,



Malcolm R. Currie



UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

SEP 18 1973

Mr. Philip Charam
Deputy Director
Resources and Economic
Development Division
General Accounting Office
Washington, D. C. 20548

Dear Mr. Charam:

The Department of the Interior's Bureau of Reclamation has reviewed your draft report, "Need for a National Weather Modification Research Program." Their comments in which I concur, state that less than full interagency participation in the ICAS efforts has been due primarily to financial and scientific reasons rather than a lack of organization or cooperation.

The ICAS position, concurred in by the Department through its representative, regarding the subject of an implied "national program" in weather modification has been stated formally several times, the most recent in its review of reports by the National Academy of Sciences Committee on Atmosphere Sciences (NAS/CAS) and the National Advisory Committee for the Oceans and Atmosphere (NACOA). This position has been summarized by Dr. Edward P. Todd, Chairman of ICAS as follows:

"Assignment of a lead agency responsibility...would place the selection of priorities in weather modification R&D activity for all agencies in the hands of a single one. The ICAS feels, to the contrary, that for the foreseeable future there is a considerable tactical advantage in having a number of agencies making contributions to the R&D concepts underlying weather modification rather than....to reduce the diversity of intellectual and managerial inputs by relegating all but one agency to the role of potential users permitted to participate only in specifying 'requirements'."

Although grouped under the heading of weather modification, the equipment and technique, atmospheric data and models, decision-making processes, types of people and environment involved, and basic hypotheses are significantly different for each of the major forms of weather modification, such as: precipitation management, severe storm abatement, fog dissipation, lightning modification, or hail suppression.

APPENDIX V

These technical differences, difference in objectives, and diversity of problems in each area having differing priorities for solution argue for a separate lead agency for each major type of activity. Mission-oriented lead agencies would also be more responsive to public interest in each case.

We believe that the GAO erred in looking at weather modification as a single area of effort which could be defined as a program. It would have been more realistic to review the need, adequacy, and coordination of a "national program" in each of the specific areas listed above.

The apparent consistent recommendations cited by the GAO from "independent" advisory committees for a single lead agency can partially be attributed to a few individuals who have pressed for this concept in the face of a majority of agency recommendations against it. The science of weather modification is proving to be very complex, and making progress with limited resources is slower than earlier projections anticipated. This slower progress cannot, however, be blamed on improper organization or lack of coordination.

We believe that the ICAS is an adequate mechanism for coordination of Federal weather modification activities, and that implementation of many of its recommendations for a "national program" in weather modification is primarily dependent upon adequate funding of each of the activities included therein.

We appreciate the opportunity to comment on the report in draft form.

Sincerely yours,



Allan L. Reynolds
Director of Survey and Review

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550



OFFICE OF THE
DIRECTOR

OCT 4 1973

Mr. Morton E. Henig
Associate Director
Manpower and Welfare Division
U. S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Henig:

Reference is made to your letter of August 6, 1973, requesting comments on the General Accounting Office draft report entitled "Need for a National Weather Modification Research Program."

Our comments on the draft report, presented in the following paragraphs, consist of (1) some general observations concerning the principal thrust of the report, (2) specific comments identified with pertinent sections of the draft report, and (3) some conclusions of our own.

First, we believe that the level of effort devoted to weather modification as described in the draft report may be misleading. The report states that weather modification research is but one part of atmospheric sciences research, and only briefly refers to total atmospheric sciences research expenditures. However, much of the research going on in the atmospheric sciences, other than that specifically identified as weather modification research, relates either directly or indirectly to the weather modification field. To obtain a really comprehensive understanding of the weather modification effort, it would be necessary to examine all such research, a lengthy and difficult task.

The GAO Report asserts that a national program is necessary. We are prepared to believe that development of weather modification is a valuable opportunity and potential national asset; however, the report does not show evidence that supports this assertion. Rather the GAO cites a number of studies that have previously been prepared by other groups. These studies, too, asserted a need for a national program in weather modification, but none of them were able to establish clearly the priority of this national need among competing societal problems. Assertions that current methods of coordination are not adequate do not justify the need for a lead Federal agency, but merely more effective methods of coordination.

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The GAO Report specifically notes that we lack basic knowledge about the atmosphere. It is our opinion that seeking information about the fundamentals of this field is the first order of business. We also feel that a consistent pattern of basic research will provide the theoretical basis for a sound weather modification research program, the results of which will supply the Federal mission agencies and the national interest with additional alternative solutions which can be applied to national problems that exist or arise.

The following specific comments are identified with the comments in the draft report.

1. In several places in the GAO Report, comparisons of research expenditures between 1959 and 1973 are made. The rules for fund reporting in this area of research have changed several times over that time interval. It is possible to make comparisons of orders of magnitude but no comparisons should be made quantitatively.

[See GAO note, p. 39.]

4. Page 14 - Regarding the National Hail Research Experiment (NHRE), [See GAO note, p. 39.]

The NSF, through its executive agent, the National Center for Atmospheric Research (NCAR), has achieved excellent progress in the NHRE. The Project Director of NHRE has reported cooperation among the participating organizations. The design data are being

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obtained in the fashion called for in the NHRE Plan. The only impediment to progress which has not been overcome, according to the Director, has been a lack of sufficient, suitable meteorological situations which produce potential hail clouds.

5. Page 22 - The report states that the Special Commission on Weather Modification had taken the position that "... certain aspects had reached the applied research and operations phase." Current opinion in the scientific community generally is that present weather modification activities are not sufficiently supported by scientific understanding. Sound theory must precede operational application to insure that total consequences are known in advance. It should be noted that RANN/NSF is an agency which addresses itself to selected weather modification problems, and although it has no desire to do what the mission-oriented agencies can do, RANN has capabilities to bridge the gaps which exist between basic research and operational projects.
6. Page 28 - The report states that the Secretary of Commerce, commenting on the first annual report of the National Advisory Committee on Oceans and Atmosphere (NACOA), agreed with the NACOA recommendation for a central focus for weather modification activity in the Federal Government. This agreement did not reflect the position of all Federal agencies concerned. The NSF, for example, endorsed the National Pilot Project and Pilot Project Lead Agency mode as defined in Report 15A of the Interdepartmental Committee for Atmospheric Sciences (ICAS).

[See GAO note, p. 39.]

8. Pages 34-39 - The discussion of issues in NHRE are, in part, misleading. The heading "Current Problems" is inappropriate since many items discussed have been resolved and the project is on schedule. In addition, it is worth noting that a fundamental mechanism for establishing coordination in multi-agency programs has been overlooked. This mechanism is to centralize the flow of funds, that is, to "put all the money where the problem is." Had NSF been given the funds to subcontract for essential services to other agencies for their efforts in NHRE, it is unlikely that the coordination difficulties would be developed. Fortunately, the difficulties that did arise were minor and have been overcome.

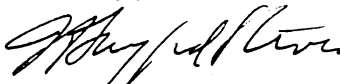
APPENDIX VI

[See GAO note, p. 39.]

Finally, we have concluded that the present scheme of National Pilot Research Projects, with assigned lead agencies, is a sound way in which to proceed and one which will produce viable alternatives through weather modification techniques for employment by the mission agencies of the Government in accomplishing their purposes. This mode of operation should, of course, be subject to periodic reexamination and appropriate adjustment if warranted by the existing circumstances.

We appreciate the opportunity to comment on the GAO draft report, and trust that the foregoing comments will be helpful.

Sincerely yours,



H. Guyford Stever
Director

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D. C. 20503

September 12, 1973

Mr. Morton E. Henig
Associate Director
General Accounting Office
Manpower and Welfare Division
Washington, D. C. 20548

Dear Mr. Henig:

This is in response to your letter of August 6 requesting OMB comments on the draft report, "The Need for a National Weather Modification Research Program." OMB comments are made in relation to what we perceived to be the primary GAO findings and conclusions.

I. Main GAO Conclusion: That a national program (and a lead agency) are needed to pull together the fragmented, Federally supported weather modification research activities. This conclusion is based on the GAO investigation and studies by research groups who, over the last decade, have identified problems in the weather modification area as:

- ineffective coordination
- fragmented research
- insufficient funds, inefficiently applied
- lack of single agency responsibility

OMB Comment: The point on ineffective coordination of research projects is not supported by fact. Weather modification research is well coordinated by the Interdepartmental Committee on Atmospheric Sciences (ICAS). ICAS meets monthly and provides members and observers the opportunity to exchange information in a timely manner. Interdepartmental coordination of weather modification activities has been, in our opinion, achieved through the efforts of ICAS and the member agencies in an exemplary manner.

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President Nixon has proposed a reorganization plan to form a Department of Energy and Natural Resources (DENR). The new Department will consolidate many Federal programs in atmospheric, oceanic and solid earth sciences - including elements of weather modification research from Agriculture - Forest Service, Commerce - NOAA, and Interior - Bureau of Reclamation. These agencies conduct weather modification research on precipitation, lightning, hurricanes and other severe storms, the socio-economic, environmental, and legal impact of weather modification and on inadvertent modification of the weather. This reorganization proposal will have many such salutary effects in the scientific areas dealing with air, oceans, and earth. In weather modification, it will be a primary focus for civilian research activities, although we will continue to support efforts by agencies to solve problems in their areas of interest with mission supporting research.

We view weather modification research not as a panacea but as an option, a possible means not as an end. A means in this sense is a technique that may achieve a particular objective. An example is the objective of mitigation of the impact of natural disasters. There are many techniques other than weather modification to attain this objective, for example, improved land use planning, community preparedness and stronger building codes. We believe the mission agencies rather than a single centralized agency should conduct the type of research activities they believe most suited to the national problems faced by them. Consequently, we believe that some consolidation of weather modification is desirable but would not necessarily conclude that all such research should be concentrated or that a lead agency approach for all generic weather modification research is preferable. In our opinion, the DENR proposal will accomplish the appropriate degree of consolidation.

Each weather modification research project is different because of the different nature and technologies of the various projects themselves. OMB has recognized this difference and has instructed particular agencies to concentrate their efforts in specific areas; Interior in precipitation, Commerce in severe storms, principally hurricanes, NSF in hail and so forth. There is inevitably some overlap, for example, in severe storms research between all projects because thunderstorms, tornadoes, and hailstorms have some common characteristics. The projects, however, are significantly different

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to proceed under the direction of a single agency. In effect, therefore, there are lead agencies for specific types of weather modification research, related as stated earlier to mission objectives.

[See GAO note, p. 39.]

- c. -- a national program with goals, objectives, priorities, and milestones conforming to identified needs.
- a plan to define and reassign, if appropriate, the responsibilities of all Federal agencies that provides support or conduct weather modification research.
- a plan to allocate resources to the national program elements.

OMB Comment: As stated earlier, in response to the main GAO conclusion, we believe a highly centralized program would be less effective than the alternative of permitting mission agencies to evaluate weather modification potentialities as one option in problem solving. Furthermore, the facilities and the technologies required to undertake the research vary greatly among problems and agencies. There does not appear to be sufficient evidence in our opinion to conclude that combining these assets, given the diverse informational

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requirements and the relative priority for weather modification, would result in increased effectiveness. To the contrary, we believe such a combination would put undue emphasis on a technology that is, as yet, mainly in the research (versus operations) stage. This emphasis could detract from adequate consideration of operational techniques for achieving goals and objectives.

[See GAO note, p. 39.]

III. Other OMB Comments:

A. Level of funding

The funding level for research applicable to weather modification is understated in your draft. Due to the lack of understanding as to why certain events occur in weather modification, a great deal of general research in atmospheric sciences is applicable to weather modification. For example, much of the research in physical meteorology contributes directly to enhancing knowledge in weather modification. Your draft, however, leaves the impression that a summation of the weather modification project budgets will indicate the level of Federal funding in this field. It has been estimated that this limited view understates applicable research by at least \$50 M.^{1/}

As to the specific size of project budgets, we conducted a review of Federal weather modification programs prior to formulation of the 1973 budget. Our conclusion was that we should recommend the continuation of research in this field, accelerating in some areas, decreasing in others.

^{1/} Informal estimate from ICAS.

For example, we believe the hurricane modification research conducted by Commerce - NOAA, may, if feasible, have significant benefits. Accordingly, we recommended an increase in funding in this area in 1974 for capital equipment preparatory to conducting research experiments in the Pacific.

Because of this need for additional knowledge, however, we consider any decision regarding the Federal role in weather modification operations - especially in the suppression of severe storms - to be very premature at this time. If suppression proves feasible, given today's thinking and technology, the application of this knowledge would appear to be enormously expensive. This underscores our earlier statement that weather modification should not be viewed as a panacea in problem solving but should be developed, through research, as an option.

To imply that the project budgets are subcritical or to support citations to that effect is a rather narrow view. Our belief is that the adequacy of weather modification budgets must be viewed in context of the agencies' other priorities. To meet President Nixon's FY 1973 expenditure ceiling, many agencies were forced to make difficult management and budgetary decisions. Where project budgets were reduced to accommodate other agency goals, one must assume that weather modification research was a relatively lesser priority. The actual size of the budgets, therefore, should not be judged out of context with other programs conducted by the agencies.

B. Public vs. Private Role in Weather Modification Operations

Our position is that weather modification operations, as opposed to research, should be carried out by the private sector wherever possible. An exception to this may be hurricane or other severe storm modification. If such an activity proves feasible, the size of the investment required to modify these storms and their interstate impact seem to suggest Federal participation. In most other areas, however, the proper domain for operations seems to be the private sector - responding to local needs. In these cases, the Federal Government's primary role has been and should be as an advisor to State and local municipalities.

APPENDIX VII

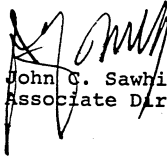
C. Public Reaction

State laws vary from regulation to prohibition of weather modification experiments and operations. It is noteworthy, however, that in a recent referendum in a farming community in southern Colorado on the question of weather modification the voters overwhelmingly rejected a proposal to modify the weather to benefit local barley growers. Because there is so much to be learned in weather modification research, one might conclude that widespread use and acceptance of operational weather modification may be more of a future rather than present concern.

There are, as mentioned earlier, in the private sector, entrepreneurs conducting rain-making operations principally in the western U. S. Their existence is proof of acceptance by certain segments of the population. These operations, however, should not be inferred as general societal acceptance of weather modification.

We appreciate the opportunity to comment on your draft report.

Sincerely,



John C. Sawhill
Associate Director



ASSISTANT SECRETARY
FOR ADMINISTRATION

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

September 27, 1973

Mr. Richard W. Kelley
Associate Director, RED Division
U. S. General Accounting Office
400 7th Street, S.W.
Washington, D. C. 20590

Dear Mr. Kelley:

RECEIVED
This is in response to your letter of August 9, 1973, requesting the Department of Transportation's comments on the General Accounting Office's draft report on weather modification research programs.

[See GAO note, p. 39.]

The General Accounting Office concludes that a national program (with a lead agency approach) is needed to pull together the fragmented Federally-supported weather modification research activities. We believe some consolidation of weather modification is desirable, but would not necessarily conclude that all such research should be concentrated, or that a lead agency approach for all generic weather modification is preferable.

Sincerely,

A handwritten signature in black ink, which appears to read "William S. Heffelfinger".

William S. Heffelfinger

APPENDIX IX

PRINCIPAL OFFICIALS OF THE DEPARTMENTS
AND AGENCIES RESPONSIBLE FOR ADMINISTERING
ACTIVITIES DISCUSSED IN THIS REPORT

| | Tenure of office | |
|---|------------------|-----------|
| | From | To |
| <u>DEPARTMENT OF AGRICULTURE</u> | | |
| SECRETARY OF AGRICULTURE: | | |
| Earl L. Butz | Dec. 1971 | Present |
| Clifford M. Hardin | Jan. 1969 | Nov. 1971 |
| ASSISTANT SECRETARY, CONSERVATION, RESEARCH, AND EDUCATION (note a): | | |
| Robert W. Long | Mar. 1973 | Present |
| Thomas K. Cowden | May 1969 | Mar. 1973 |
| Vacant | Jan. 1969 | May 1969 |
| John A. Baker | Aug. 1962 | Jan. 1969 |
| CHIEF, FOREST SERVICE: | | |
| John R. McGuire | Apr. 1972 | Present |
| Edward P. Cliff | Mar. 1962 | Apr. 1972 |
| <u>DEPARTMENT OF COMMERCE</u> | | |
| SECRETARY OF COMMERCE: | | |
| Frederick B. Dent | Feb. 1973 | Present |
| Peter G. Peterson | Feb. 1972 | Feb. 1973 |
| Maurice H. Stans | Jan. 1969 | Feb. 1972 |
| ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (note b): | | |
| Robert M. White | Feb. 1971 | Present |
| Robert M. White (acting) | Oct. 1970 | Feb. 1971 |

^a Title changed from Assistant Secretary, Rural Development and Conservation, in January 1973.

^b NOAA was formed in October 1970 pursuant to Reorganization Plan Number 4, consolidating Environmental Sciences Services Administration with programs and elements from other Federal organizations pertaining to marine sciences.

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| Tenure of office | |
|------------------|----|
| From | To |

DEPARTMENT OF DEFENSE

SECRETARY OF DEFENSE:

| | | |
|------------------------------------|-----------|-----------|
| James R. Schlesinger | July 1973 | Present |
| William P. Clements, Jr., (acting) | Apr. 1973 | July 1973 |
| Elliot R. Richardson | Jan. 1973 | Apr. 1973 |
| Melvin R. Laird | Jan. 1969 | Jan. 1973 |

DIRECTOR OF DEFENSE RESEARCH AND

ENGINEERING:

| | | |
|---------------------|-----------|-----------|
| Malcolm R. Currie | June 1973 | Present |
| John S. Foster, Jr. | Oct. 1965 | June 1973 |

DIRECTOR OF ADVANCE RESEARCH PROJECTS

AGENCY:

| | | |
|--------------------|-----------|-----------|
| Stephen J. Lukasik | Apr. 1971 | Present |
| Everhardt Rehtin | Nov. 1967 | Apr. 1971 |

DEPARTMENT OF THE INTERIOR

SECRETARY OF THE INTERIOR:

| | | |
|--------------------------|-----------|-----------|
| Rogers C. B. Morton | Jan. 1971 | Present |
| Fred J. Russell (acting) | Nov. 1970 | Jan. 1971 |
| Walter J. Hickel | Jan. 1969 | Nov. 1970 |
| Steward L. Udall | Jan. 1961 | Jan. 1969 |

ASSISTANT SECRETARY, LAND AND WATER

RESOURCES:

| | | |
|----------------|-----------|-----------|
| Jack O. Horton | Mar. 1973 | Present |
| James R. Smith | Mar. 1969 | Feb. 1973 |
| Kenneth Holum | Jan. 1961 | Mar. 1969 |

COMMISSIONER, BUREAU OF RECLAMATION:

| | | |
|---------------------------|-----------|-----------|
| Gilbert G. Stamm | May 1973 | Present |
| Gilbert G. Stamm (acting) | Apr. 1973 | May 1973 |
| Ellis L. Armstrong | Nov. 1969 | Apr. 1973 |
| Floyd E. Dorniny | May 1959 | Oct. 1969 |

DEPARTMENT OF TRANSPORTATION

SECRETARY OF TRANSPORTATION :

| | | |
|--------------------|-----------|-----------|
| Claude S. Brinegar | Feb. 1973 | Present |
| John A. Volpe | Jan. 1969 | Feb. 1973 |
| Alan S. Boyd | Jan. 1967 | Jan. 1969 |

APPENDIX IX

| | <u>Tenure of office</u> | |
|--|-------------------------|------------|
| | <u>From</u> | <u>To</u> |
| ADMINISTRATOR, FEDERAL AVIATION | | |
| ADMINISTRATION: | | |
| Alexander P. Butterfield | Mar. 1973 | Present |
| John H. Shaffer | Mar. 1969 | Mar. 1973 |
| David D. Thomas (acting) | Aug. 1968 | Mar. 1969 |
| Gen. William F. McKee | July 1965 | July 1968 |
| <u>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION</u> | | |
| ADMINISTRATOR: | | |
| James C. Fletcher | Apr. 1971 | Present |
| George M. Low | Sept. 1970 | Apr. 1971 |
| Thomas O. Paine | Oct. 1968 | Sept. 1970 |
| <u>NATIONAL SCIENCE FOUNDATION</u> | | |
| DIRECTOR: | | |
| H. Guyford Stever | Feb. 1972 | Present |
| Raymond L. Bisplinghoff (acting) | Jan. 1972 | Feb. 1972 |
| William D. McElroy | July 1969 | Jan. 1972 |
| Leland J. Haworth | July 1963 | June 1969 |