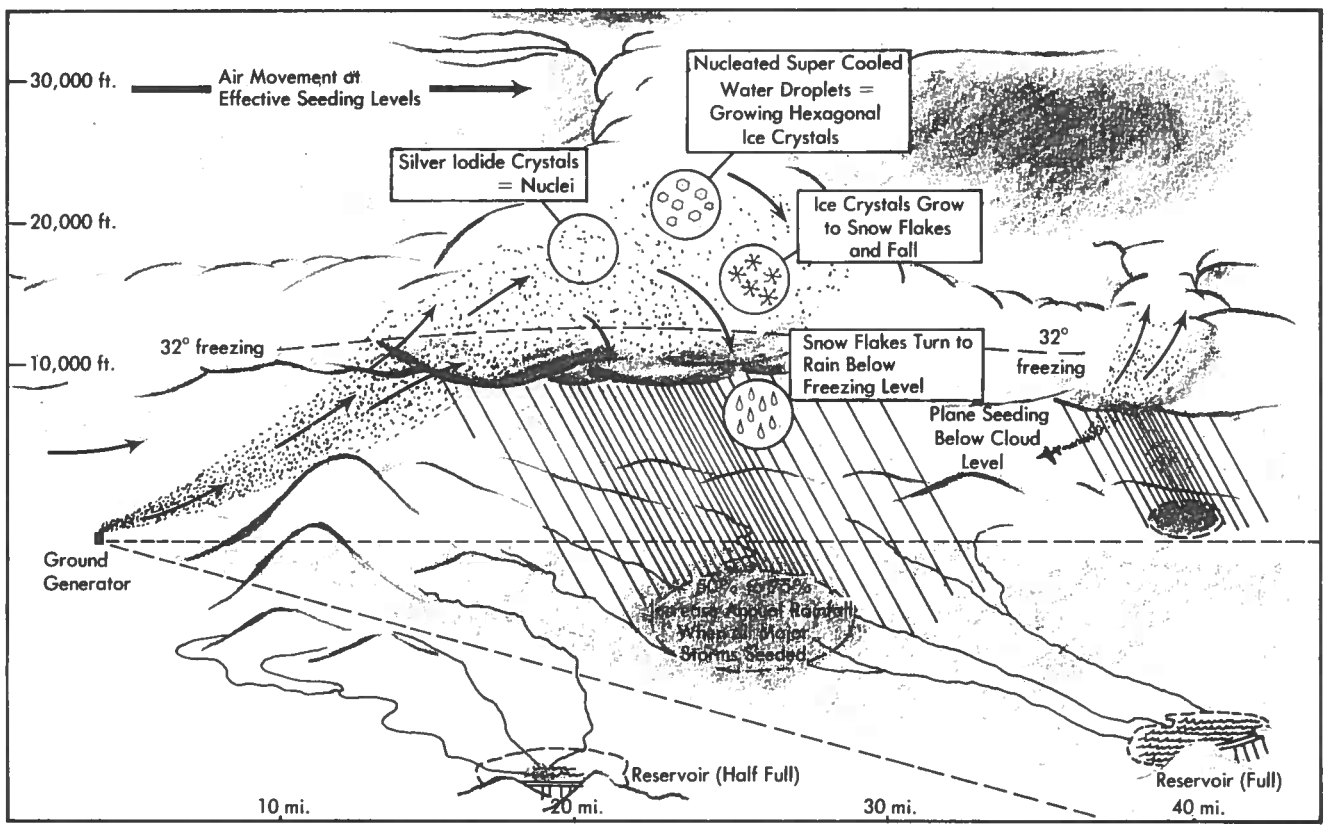


Drawing shows how silver iodide seeding of rainfall clouds works. Both stationary and airborne generators are used to seed clouds.

Project Skywater

Rainfall Patterns Need to Be Improved

GOVERNMENT weather scientists apparently are becoming convinced that nature's rainfall patterns can be improved.

Out of about 20 billion tons of water that flow daily over the continental United States, borne by prevailing west-to-east winds, only 10 percent is deposited as snow or rain on land areas. That which falls is unevenly distributed.

Man's efforts to do something about rainfall may be traced to prehistoric times. Success in them is not so readily identified. Within the past 25 years scientific procedures such as cloud seeding to produce more moisture from available clouds has been gaining in public credence.

For that reason an extensive program of research has been set up under the title "Project Skywater." In 1961 Congress authorized the Bureau of Reclamation, U. S. Dept. of Interior, to explore the potential of weather modification. This is being done under direction and co-ordination of the Bureau's Division of Atmospheric Water Resources Management, Denver, Colo., with studies contracted in more than a dozen states by various institutions.

STATED OBJECTIVES of the work are to identify, explore, and establish the process by which clouds form and produce precipitation, and how these phenomena might be beneficially influenced by man.

The Bureau has recently published a compilation of research reports on these projects. Work done in laboratories, using scale models and computers, as well as field work, appear to substantiate in large measure previously advanced ideas regarding cloud seeding. Subsequent statements in this article are from these reports.

Meteorology Research Inc., one of the contractors, said that "summertime cumulus modification is on the threshold of a major breakthrough" toward operational weather modification. However, it was assumed that it would be profitable to seed isolated cumuli in the southwestern United States "only under certain environmental conditions."

ONE AIM of cloud seeding is to increase the size of clouds so they will produce more rain. To be effective in "stimulating the dynamics" of isolated clouds, it was pointed out that the seeding must be done early enough in the cloud's lifetime to insure that the nucleation occurs during the growing period.

Studies show that seeded clouds grow larger in horizontal as well as vertical dimension, have a longer rain period, and have a higher rainfall than do the non-seeded cumuli. Studies were concerned with developments in both warm and cold cloud formations.

Texas A&M University made some 1,000 aircraft penetrations of warm clouds to evaluate their potential for precipitation. Most of the clouds studied were 6,000 to 10,000 feet in vertical dimensions with bases at about 4,000 feet above sea level. These clouds invariably were found to yield at least light rain by the time they have reached this size. Failure of many of them to grow larger was thought to be due to the dissipating effects of the rain.

Values of the maximum and average water contents for a cloud unit varied greatly. Water content tends to change with height, increasing up to levels about 9,000 feet above base, with a suggestion of a rather radical decrease above that. Relative water contents of the warm cumulus clouds in Texas tended to be larger than those of subtropical oceanic clouds and of hurricane clouds.

THE TEXAS A&M report observes that although a cloud is not likely to continue growing after it reaches 10,000 to 13,000 feet, extracting available water might not be the only possibility. "This 'milking' logic assumes that nothing can be done to enhance the release of energy to make the cloud grow into something more productive," it says.

In the direct water extraction process, one would want to use very large nuclei which would form drops large enough to fall quickly without much added growth. In the energy-release method this would not be wanted because premature rainfall would stop the cloud's growth.

"Before seeding a cloud one must know what its intentions are," the Texas report notes. A cloud that is destined to break away into a big one under its own energy drive would not be suitable for seeding. A seedable cloud would be one that would be stunted in its growth if left alone.

THE NORTHERN Great Plains project began in 1969 in Western North Dakota. Aircraft equipped with silver iodide generators were used to seed suitable cold clouds either at cloud base or at cloud level. For comparison, no seeding was done on one-fourth of the days when clouds considered suitable for seeding were present.

Physical factors that comprise a cloud's ability to produce moisture were long ago established as including temperature, moisture content, air flow, presence of naturally occurring freezing and condensation nuclei, among others.

Like a chemical catalyst, says the Northern Plains report, ice nuclei have the ability to trigger dramatic changes within a cloud — a conversion of water vapor to water droplets to ice crystals, with an accompanying release of heat. Without a sufficient number of ice nuclei, clouds even with great volumes of water may glower and threaten endlessly but still decline to send their moisture earthward.

TOOLS AND TECHNIQUES to accurately measure ice nuclei in the atmosphere are being developed. As storms are constantly in motion the ability to "target" rain or snow from a seeded storm to a particular area poses a major challenge.

Phases of this problem are being studied in several places. New Mexico State University undertook to measure diffusion processes of artificial nucleants into selected storm systems. It noted that actual dimensions of the nuclei plume are difficult to predict and that target and control areas cannot be precisely delineated.

At South Dakota School of Mines & Technology a study was set up to define effects of seeding over several thousand square miles. Illinois State Water Survey has tried to provide quantitative estimates of the effects of cloud seeding on crop production.

State of Washington set up a program to determine the mechanisms by which precipitation develops in water storms over the Cascade mountains, and to investigate the feasibility of increasing and redistributing snowfall in this area by seeding clouds.

Earlier work there indicated that material dispersed from ground-based generators was likely to be confined to the valleys rather than to be carried up into the clouds.

IN CALIFORNIA, Aerometric Research produced evidence that increases in precipitation from seeded convective bands was occurring in areas well removed from the seeding source. A dynamic response to seeding within the convective band itself was thought to be the reason for a downwind increase in precipitation, but the reason for a skip in rainfall between the primary seeding effect and the downwind area was described as "obscure."

Colorado State University used scaled topographic models and laboratory techniques to study the transport and dispersion of cloud seeding material over mountainous terrain. The potential for increase of winter precipitation is estimated at 30% in the Colorado River Basin Pilot Project area. Randomized operations on a 60% seed, 40% no-seed basis would yield an 18% increase in winter precipitation.

TECHNIQUES for seeding clouds are being tested at a number of locations, including acetone generators, pyrotechnic devices, fusees, and vertical-fall pyrotechnics. Although silver iodide crystals are the kind most commonly used, the University of Denver tested a total of 75 compounds as nuclei and 22 were found to be effective. The University of Nevada is searching for a fluorescent dye which can be traced but which would not reduce effectiveness of the nuclei.

This could be important for several reasons. One is the possibility that clouds may be inadvertently seeded by air pollution. In Utah State University studies, the geographic location of industries, population centers and traffic concentrations in the Salt Lake Valley suggested that a significant number of ice-forming nuclei are coming from these sources.

It was noted that existence of sufficient background nuclei over the Salt Lake Valley could affect the results of deliberate cloud seeding activities. Overseeding is a possibility.

In Florida, possible effects of nuclei from fires that burned some 52,000 acres of vegetation during the

Continued on Reverse Side

FOR TWENTY YEARS editors of The Farmer-Stockman have been interested in the possibilities of improving our rainfall patterns by weather modification. As of now, we specifically mean cloud seeding, as described in this report on current research projects. We are presently checking out and developing other sources of information on the subject. Look for more articles in The Farmer-Stockman soon! — EDITOR.

Rainfall

Continued from Opposite Page

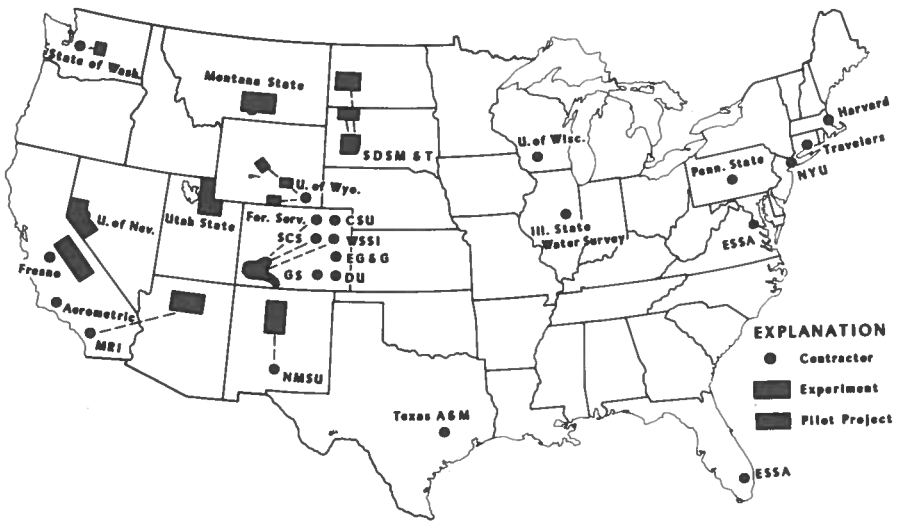
1967 drouth were studied in an Environmental Science Services Administration project. It was shown that the rain fallout from the large cumuli was reduced slightly and rainfall from smaller clouds could be significantly reduced if they formed in the vicinity of the fires.

THIS SAME PROJECT revealed other problem areas that might arise in connection with cloud seeding programs. A series of cloud seeding experiments was reduced to a single effort in 1970 for two reasons. First, heavy rains and flooding in March damaged crops severely just before the April tests were scheduled. Then in April the tomato harvest was under way and growers did not want rain. A delicate public relations situation developed, with political undertones, and further cloud seeding was postponed.

Closely associated with this type of development is the question of who should decide when to seed clouds and how should responsibility be established in the event of damage or loss. A study of legal aspects of cloud seeding was set up at Harvard University.

One of the obstacles Harvard encountered was to find a way to prove "causation" in weather modification for the purpose of equitably compensating parties who may suffer losses.

THE HARVARD report cited several suggestions for creation of a federal regulatory commission to pre-empt the entire field of weather modification, perhaps set up along lines of the Atomic Energy Commission. Disagreement exists over which agency or agencies should have jurisdiction, in the event federal legislation is passed covering weather modification.



Map shows location of studies made during 1970 fiscal year in various aspects of cloud seeding to increase amounts of rainfall.

A major legal obstacle to holding states liable is the doctrine of sovereign immunity. The eleventh amendment would bar a suit by a private individual against a state in the federal courts, and it might not be possible to force a state to entertain lawsuits against itself in its own courts.

Obviously, human nature and varying requirements or preferences will add to the scientific problem of weather modification. Even though farmers may agree that more rain is needed, they may have a hard time concurring on a date if one has hay on the ground to be baled, another is preparing to plant, a third has crops that need watering, and a nearby rancher has stock tanks that need to be filled.

While weather modification may be regarded largely as a rural activity, it must be noted that water for lakes and reservoirs that serve cities and towns comes mainly from the countryside. Thus the potentialities for improved precipitation through cloud seeding should be of general interest to the entire population.

Editors of The Farmer-Stockman are convinced that we can do much more about alleviating our weather problems than we have done in the past. We will continue to provide our readers with a reliable long range weather forecast from a well-informed source that has had long experience in the business. We also will bring you available information about weather modification.

This could be the year we ought to do something about the weather besides complain!

Reprinted from July 1971 issues of

The Farmer-Stockman

Kansas-Oklahoma-Texas-New Mexico

Our Editorial Policy

More Rain When Needed

By Ferdie J. Deering

Editor & Manager,
The Farmer-Stockman

IT IS NOW more than 25 years since Dr. Irving P. Krick returned from military duty and set up in business with the weather.

On assignment with the U. S. Military forces based in England, Dr. Krick had been successful in forecasting clearing weather needed for pinpoint bombing after Allied troops landed on the coast of France.

Back in the United States, Dr. Krick had undertaken to provide weather forecasting services needed by gas companies in regard to advance preparations for peak fuel loads, by bathing suit manufacturers who wanted to know when the weather would turn warm, and for other types of businesses.

Editors of The Farmer-Stockman had been trying to get the U.S. weather bureau to provide a long range forecast for farmers, but the best we could get was a report on what the weather had been in the same month a year earlier. In this country that isn't a whole lot of help. So we turned to Dr. Krick and he agreed to provide The Farmer-Stockman with a long-range forecast, first to be published regularly in any farm magazine. He's still providing the service.

About the same time, Dr. Krick advanced the idea of seeding rain clouds to extract more moisture from them. Other scientists had established that only a fraction of the moisture that crosses the country falls as snow or rain. They had also learned that this could be increased if suitable nuclei were provided for collecting moisture. Dr. Krick assembled the information, added some research of his own, and took the whole idea to the field.

Results of these efforts were some successes, other instances where hoped-for results did not materialize, and a considerable amount of controversy, largely generated by government bureaucrats. They weren't providing long range forecasts and they didn't believe in cloudseeding, but they didn't want anybody else fooling around with the weather, which they seemed to regard as their own "private public property."

After several years of profitless efforts to establish cloud seeding as a means of increasing available moisture, Dr. Krick was compelled to take his work into foreign countries to keep it going. The relentless attacks from Washington undermined public confidence in the theory, regardless of results.

The bureaucrats then turned their attention to each other, disputing which bureau should operate the weather and related services. Finally, the Bureau of Reclamation got its bid in effectively and in 1961 Congress designated it as the agency to explore the potential of weather modification.

In reviewing statements published in 1950 and 1951 by Dr. Krick, we find that a large percentage of the research merely verifies his claims. None of it contradicts his pioneering procedures, as far as we could determine. The major difference seems to be that Dr. Krick has tried his theories in the field, testing many different cloud formations and seeded entire storm systems, while much of the Bureau of Reclamation research has been done in laboratories and has yet to be fully field tested. One of Dr. Krick's projects in New Mexico has been in operation for 21 years and was green this spring when most of the surrounding country was still very dry.