DEEP CREEK REVIEW

A Drop in the Bucket

Art Rangno
Steve Suloway

Preempting God

E G & G, Inc. of Durango is completing its fourth year of cloud seeding in the southeastern San Juan mountains, under contract from the US Interior Department's Bureau of Reclamation. The target area is, very roughly, a triangle going from Durango to Pagosa Springs to Creede.

Most of this area is above 9500 feet in elevation, government owned, and sparsely populated. It is a high-production snowpack area which contributes to the flow of the Colorado River and its tributaries. The purpose of the seeding is to create more water by increasing the winter snowpack.

What the scientists are doing is releasing silver iodide from 33 generators on the ground into the atmosphere upwind (hopefully) of selected cloud formations, and measuring the results through 200 monitoring units around the area.

Art Rangno, one of the E G & G meteorologists running the seeding program in Durango, wrote "Does It Really Work?", the first section of the article below. The rest of the material was compiled by Deep Creek from Interior Dept. publications and from the files of Joyce Jorgensen, editor of the Ouray County Plaindealer.

Does it really work?

One of the larger cloud seeding operations ever undertaken in the United States is currently under way in southwest Colorado. In its fourth season, the Colorado River Basin Pilot Project was expected to produce an increase in snowfall over 1300 square miles of the San Juans when storms of certain winds and termperatures were "seeded" with silver iodide. Some of the storms with these characteristics were to be seeded while similar storms were to be left untreated so that two groups of storms of similar characteristics could be compared.

killed a hunter (no proven connection to seeding); and poor results from the winter of 1972-73, when natural snowfall was extremely heavy.)

The operation has now been extended for another year.

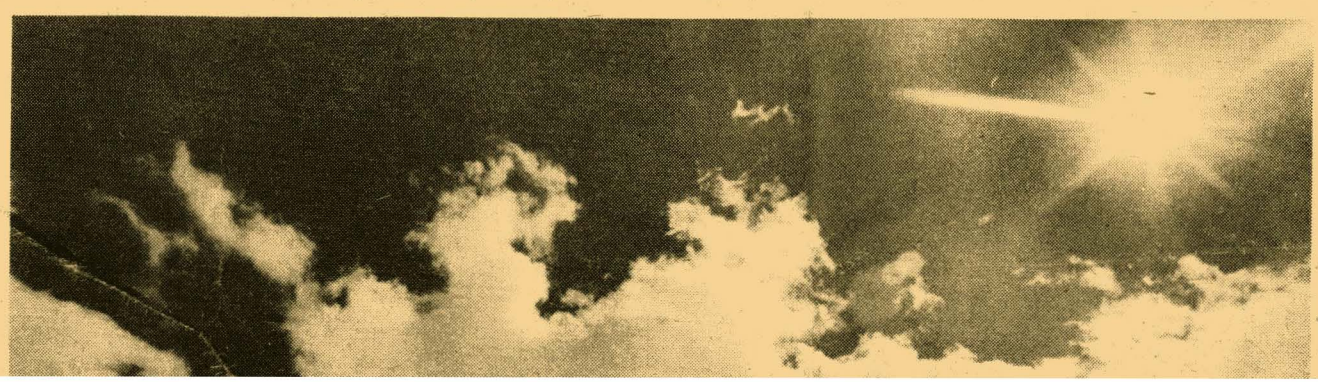
But let's back up for a moment. Why would the injection of silver iodide be expected to result in more precipitation anyway? The answer is to be found in the fact that water droplets of the size found in clouds (about 0.002 inches or less in diameter) do not freeze at 32°F as does water in your refrigerator. They can sometimes remain liquid even at temperatures of -30 or -40°F--they are "supercooled." For appreciable precipitation to reach the ground, both supercooled droplets and ice crystals are required. When ice and liquid water exist in the same cloud, the ice crystals will grow while the liquid droplets evaporate. As the crystals grow they begin to settle out of the cloud system as snowflakes.

Why add silver iodide? Because the nuclei (microscopic pieces of material--usually dirt) about which ice crystals begin to form are much more rare in cloud systems that are the materials about which the liquid droplets from. Clouds at temperatures well below freezing, say as cold as 10 or 15°F are commonly composed completely of

tion increases due to seeding with silver iodide. Ironically, one of these, the experiment conducted by Colorado State University at Climax, Colorado, is the experiment that formed the basis for the Pilot Project in the San Juans. It has defied duplication.

Why haven't the Climax experiments been transferable to the San Juans? First of all the change of location introduces new factors. What was good for Climax may not be good for Wolf Creek Pass. Careful observations of the cloud structure in the vicinity of the San Juans suggest striking differences between the two locations. At Climax there were many, many hours of clouds thousands of feet thick of a type that, the experimenters, concluded, did not precipitate unless seeded. In the San Juans such clouds form a trivial portion of the winter season's cloudscape. This is a crucial point: the Climax data indicated that there was no seeding effect when precipitation was going to occur naturally but that the increases were due to the initiation and prolongation of snowfall when it otherwise should not have occurred.

Another assumption which has proved to be flatly erroneous involves the location of the top of the cloud systems. At Climax, the temperature at a



Project was expected to produce an increase in snowfall over 1300 square miles of the San Juans when storms of certain winds and termperatures were "seeded" with silver iodide. Some of the storms with these characteristics were to be seeded while similar storms were to be left untreated so that two groups of storms of similar characteristics could be compared.

The application of statistical procedures to the two groups of storms will ferret out whether the differences are due to chance selection (no two storms are ever quite alike) or due to seeding. As of this writing it is apparent that when the two groups of seeded and non-seeded storms are compared over 24 hour experimental units, the differences are too slight to indicate that seeding has influenced the amount of precipitation; if seeding has increased or decreased the amount of snowfall on the San Juans, the amount is too small to be provable.

Several corporations that pay for cloud seeding operations are looking only for slight increases in precipitation. Pacific Gas & Electric of central California found that if seeding in the Sierra Nevada mountains could increase snowpack and runoff for hydroelectric power by merely five percent, it would be economically feasible. However, such an increase, while economically feasible, is practically unprovable by statistical procedures due to nature's great variations, which can go from 1/2 to twice "normal." Since it is unrpovable, the corporations are taking the chance that seeding might even decrease the precipitation by a small amount.

Why then are most cloud seeding experiments today randomized--designed so that some storms are seeded and others left unseeded--so that two groups of data are obtained when small differences in precipitation will lead to inconclusive results? The most obvious reason is that beforehand it is not known whether the results will be trivial or not, and in other cases, such as the San Juan project, sizeable and "statistically significant" results were anticipated. It was originally estimated that four winter seasons would be sufficient to demonstrate these increases. For a number of reasons both the effect from seeding and the number of storms which were selected as "experimental" have fallen well below expectations.

(The original four-year project design called for 40 seedings (out of 80 seedable storms) per year. Actually only 43 seedings occurred in the first three years. The reasons, at least in part: the elimination of half the project area, partly because of citizen protest; the Weminuche primitive area, smack in the middle of the project, where technological installations are prohibited; the dropping of the hunting season from seeding activity at State request after an avalanche

Photo by Gary Blake

liquid droplets; hence there is not growth factor and nothing falls out of the cloud. (Incidentally, the properties of these small cloud drops are such that they act like marbles or ping pong balls, bouncing off each other when they collide so that raindrops are not formed by chance collisions.) Hence the injection of silver iodide, which acts as a nucleus about which ice crystals will form--the final ingredient for precipitation. Theoretically, the amount of precipitation would be dependent on how long the growing crystal remained in the cloud system and how much water vapor was in the clouds.

Proponents of cloud seeding assume that some, or even all clouds, will release more precipitation if treated with silver iodide.

What is the scientific evidence? Surprisingly, most randomized projects have shown either no discernible effect due to seeding or statistically significant decreases in precipitation on seeded days. A small number have shown significant increases but the conditions under which the increases occurred were so varied, that one scientist, Dr. Morris Neiburger of UCLA, told the World Meteorological Organization that it is impossible to predict the effects of seeding. At an international meeting on weather modification last October, another scientist, Dr. Jack Warner of Australia, reviewed the 27 years of cloud seeding activity and cited only three experiments which unquestionably should precipita-

certain level in the atmosphere was found to be associated with snowfall increases and decreases on seeded days. It was hypothesized that this level must have been at or near the top of the clouds (although the actual location of cloud top was usually unknown). In the San Juans, therefore, we used cloud top temperature as a criterion for operation, instead of using the temperature at that "certain" level which had actually been associated with increases and decreases.

The cloud top criterion proved untenable as cloud tops varied greatly at any one time over the project area and also changed rapidly in time. It proved disastrous in terms of showing economically feasible increases in snowfall during the second and third years of operation in the San Juans.

A small advantage of precipitation logged during the first season of operation for the seeded storms (when the criterion was identical to the Climax run--the temperature at a level in the atmosphere) was obliterated during the following two seasons. The fourth (current) season's operation marked a return to the original criterion. Since it appears now that the temperature at this level has no relationship with the temperature at cloud top, the physical argument as to why increases were to be expected was dealt a blow as though a finely knit sweater began to come unraveled.

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Another serious shortcoming of the cloud-seeding-increase-argument (that there is a need for more ice crystals) is that measurements of ice crystal concentrations in clouds consistently reveal from twice as many to even ten thousand times as many ice crystals in the cloud system than can be accounted for by theory or actual counts of the particulate nuclei about which ice should form. This is a mystery which has defied explanation to this date.

"You mean to tell me that you don't even know where all of the ice crystals that nature supplies come from, and you're still assuming there is a need for even more through the injection of silver iodide?" I gues that is a little hard to believe, but that's precisely it. In fact the designer of this project, CSU Professor Lewis O. Grant, of Climax fame, notes that if these actual observations were used to predict how many ice crystals would actually be found in his theoretical clouds, there wouldn't be any need for weather modification(!). This probably sounds silly, but why do we insist that the clouds need more of these ice forming nuclei? The answere is a pragmatic one: Seeding with silver iodide at Climax was apparently successful and therefore the clouds must have needed more ice nuclei, regardless of ice crystal counts. Until the mechanism which results in the extra ice crystals is discerned, this rather weak argument is likely to be invoked by seeding enthusiasts.

Another question which has not been adequately resolved is whether increases in precipitation are just that, or merely redistribution of precipitation with no actual increase.

Other problem areas, but by no means all of them, include questions on whether the mechanism which results in all those extra ice crystals varies from storm to storm or within the same storm at different times and places: whether it can be predicted in advance; and the logistics of getting the silver iodide seeding material up into the clouds at the right time and place. This latter problem raises questions on the very frontiers of the process known as "diffusion": how substances, be they pollutants, silver iodide, or anything else are dispersed in the atmosphere. At this time only crude approximations are used in the targeting of the seeding material. However, some diffusion studies are now being undertakin in the San Juan Project by the University of Washington and the Bureau of Reclamation with the aid of a refurbished WW II Douglas B-23 designed for cloud physics studies and silver iodide sampling.

Perhaps the status of the type of cloud seeding that is being performed on wintertime storms of the San Juans is best summarized by the Nat- of the 1966 report that 'there is increasing but still somewhat ambiguous statistical evidence that precipitation from some types of storms can be modestly increased or redistributed by seeding techniques' " (emphasis mine).

While the Colorado River Basin Pilot Project may not show the expected increases under the various criteria used, it will mark another milestone in the evolution of cloud seeding technology and help clarify whether that technology is capable of producing worthwhile results.

The political story

The San Juan pilot project was very controversial when it was initiated, particularly in Ouray and Silverton, which were originally included in the proposed target area.

"What the hell do we need more snow for?" was the gist of the complaints. Will it increase avalanches, which are already severe? Who will get the extra water? What will be the ecological and ecnomic effects of greater snowpack and the resulting shorter spring season? Who are these guys anyway? Why [redacted] they ask us? Is this begin thrust upon u[redacted]ecause our population is "sparse"?

Ouray County Plaindealer editor Joyce Jorgensen led the outcry, which eventually resulted in BuRec's first public hearing on a cloud seeding project (in December 1968). A year or so later, after public pressure in the form of citizen petitions and institutional requests (Chambers of Commerce, County Commissioners), first one, then a second of the four areas of the San Juan project were dropped from the program (the Telluride-Ouray-Lake City-Silverton area, and the Rico-Purgatory area).

All sorts of questions were asked about side-effects of extra snow: wildlife calving and migration patterns; the hunting season; mining, which in many productive operations is already limited to a few months annually; ranching--also dependent on an already short season for grain and hay production; cattle and sheep summer range, which could be snow-covered for a longer period of the year; tourism; highway, street and jeep road maintenance; possible flooding from increased spring runoff; avalanches; and possible downwind water shortages as seeding unnaturally milks the clouds (perhaps) of all they contain.

Very little information was or is available on these impacts. Under public pressure, BuRec instituted the San Juan Avalanche Research Project in 1971, contracted out to the Institute for Arctic and Alpine Research at the University of Colorado. The study would be helpful to the area aside from correlations with cloud seeding. However, this project was the victim of recent budget cuts and will be terminated this summer,

In summary, the political events accompanying the San Jaun pilot project were:

--BuRec admitted the need for external regulation of cloud seeding, through public hearings and possbile legislation;

--Ecological and physical dangers were admitted and studies were initiated;

--The two northwestern sections of the project were dropped.

--Talk of legislation to provide compensation for damages began;

--The first nationwide attention to cloud seeding resulted in large part from Jorgensen's extensive coverage of the issue and the loud public clamor.

Nowadays, almost everybody in southwestern Colorado knows about the cloud seeders. Last winter ('72-'73)

winter's ('72-'73) heavy snowfall was speculatively attributed to the scientists, although it extended over a very large interstate region. This year, Montrose residents had a brutal winter and cursed the seeders. Ranchers from the normally dry San Luis Valley east (downwind) of the pilot project have protested for several years that seeding is stealing what little water they've got. (Whether or not cloud seeding affects greater areas over longer times than intended in the experiments, or whether it reduces downwind precipitation, are not definitely known, like most aspects of the field.)

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Perhaps the status of the type of cloud seeding that is being performed on wintertime storms of the San Juans is best summarized by the National Research Council-National Academy of Science Committee on the Atmospheric Sciences. Writing in 1971 the committee issued what must be considered a rather "hedgy" statement, to wit: "There has been a steady accumulation of statistical evidence supporting the conclusion

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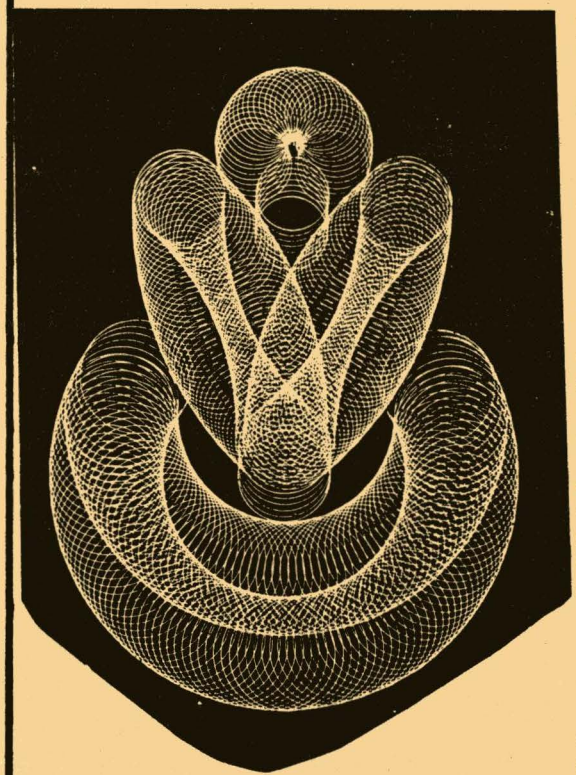
The objections have become academic because the four years of seeding haven't done anything (other than furthering abstract scientific inquiry).



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Critic Jorgensen commented last month, "The people now are overreacting . . . they're blaming the cloud seeders for everything, and that's not fair either."

The major problem that remains, now that BuRec has shown some commitment to environmental concerns and public input, is legal compensation for damages. Few clear-cut cases have emerged, and they might not very soon since so little about weather modification is clear-cut.

The flood that devastated Rapid City, South Dakota, in 1972 with water moving 12 times faster than ever recorded in the area, was widely suspected to be linked to a cloud seeding operation the day before in the mountains that include the headwaters of the rampaging creek. A state-appointed panel of inquiry, dominated by cloud seeding contractors, said later that the seeding couldn't possibly have contributed to the flood. This was suspicious to some because of the vested interst of the contractors in such a denial and the fact that cloud seeding is so unpredictable and unmeasurable that objective inquiries usually can't draw firm conclusions one way or another.

The contractors were probably the only ones qualified to look into the matter. A rancher, miner, landowner or relative of an avalanche victim would have no easy time demonstrating damage if the Rapid City case is any indication.

Federal and Colorado law at this point require detailed licensing and reporting procedures, but say nothing about liability. A complainant is not guaranteed access to contractors' data, but presumably must show proof of cause.

Environmental concerns

Pollution from silver iodide, the cloud seeding substance, is well below the danger level, according to the US Public Health Service and others.

The US Council on Environmental Quality said in February 1971 that "present evidence does not suggest dramatic ecological consequences and

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and (2) to adopt and enforce subdivision regulations. They are also empowered to make zoning regulations upon the order of the County Commissioners. The San Miguel County Planning Commission was created January 20, 1971 and subdivision regulations were adopted October 13 1971.

-zoning-

Zoning regulations and an official zoning map were adopted by the County Commissioners after publi

Zoning regulations and an official zoning map were adopted by the County Commissioners after public hearing May 15, 1972. The regulations divide the land in the county into zoning districts. In each district, certain kinds of land uses are permitted, and certain lot areas, setbacks and building heights are prescribed.

All of unincorporated San Miguel County, with the exception of a few areas near Telluride and some lands which have been subdivided, is zoned "F"--Forestry, Agriculture, and Open District. Uses permitted in this zone include single family dwellings, agriculture, forestry, lumber and ore mills, mines, quarries, outdoor recreation and public facilities such as schools, airports, cemeteries, water and sewer plants, and sanitary landfills.

certified by the State Land Use Commission for their unincorporated lands.

The state required that "subdivided land" be devined as any parcel

and certified by the state. County landowners who held their land before S.B. 35 was passed may apply for exemption of one simple split of a parcel.

Ms. McGowan and County Planner Mark Frauhiger can be reached at the courthouse, 728-3528, Box 548, Telluride.

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such changes as might occur probably would take place slowly. Relatively slight weather modification changes could be imposed upon an already highly variable climate and environmental impact would be almost unnoticed by the general public."

A 1967 study by the University of Michigan, commissioned by BuRec, reported that "Deeper snow lying on the gound longer into the summer would inhibit growth of existing trees and largely prevent establishment of new ones... A successful program to augment snowfall... could alter composition of herbaceous vegetation of the area through increased growth of parasitic fungi under the snow." Also noted was a threat to winter game range due to "tender and easily damaged vegetaion at snowbank margins."

The San Juan Ecology Project, funded by BuRec as part of the pilot project and carried out since 1970 by Colorado State University, University of Colorado and Fort Lewis College, has been attempting to determine relationships between snowfall and selected plant and animal communities. Preliminary results indicated no immediate ecological effects from increased snowfall. Both the Ecology Project and the soon-to-be-discontinued Avalanche Research Project have so far reported findings largely in terms of establishing methodologies and surveying the study areas as groundwork for possible future substantive findings.