agency, Euratom, indicates that this is easier said than done, but some informed onlookers feel that the incentives for hanging together are greater these days.

The main issue, however, remains oil—oil from the Middle East and oil from beneath the North Sea. The spectacle of the United States importing increasing quantities of Middle Eastern oil and the prospect of the United States and Japan bidding up the price of oil makes the Europeans worry.

If the oil-producing countries should withhold oil from the United States for political reasons or simply decide to keep their oil in the ground, the effect on the world market would be profound. The task for the Europeans, as one British official expressed it, is "to get as harmonious a European view as possible as quickly as possible and then to immediately bring in Japan and the U.S." There is a precedent for cooperation in the practice of European oil companies sharing supplies at times of shortage, and there is also an OECD (Organization for Economic Cooperation and Development) agreement to share oil stocks at times of interruption of supplies.

For the British, obviously, the handling of their North Sea gas and oil becomes a delicate matter. They are "viewed as a national asset," says one British official, "but we do not say we won't share. As we evolve a U.K. energy policy, it will be a U.K. aspect of a European energy policy."

The major unknowns facing energy policymakers in Britain and elsewhere seem to be the future price and availability of Middle Eastern oil and the rate at which nuclear power plants—particularly the breeders—will be ready to supply a substantial part of power demands. If the British experience of the past two decades is any criterion, however, the watchword for the planners should be to expect the unexpected.—JOHN WALSH

# Weather Modification: Colorado Heeds Voters in Valley Dispute

*What the public thinks about weather modification, rather than what the scientists know about it, will play the dominant role in the future of this science.* —From a 1971 report of the Interdepartmental Committee for Atmospheric Sciences, Washington, D.C.

The above words were written in a sympathetic spirit, and not in the spirit of scientists railing in frustration against an uninformed and potentially meddlesome public. Well that they were sympathetic, for, given the uncertainties about the effects of weather modification, there would be no justification whatever for scientists in this field to talk down to anyone. Yet public regulation of the "rainmakers" is in as undeveloped a state as weather modification itself, and only in the last few years have a few states such as Texas and Colorado enacted potentially strong and workable regulatory laws. Since the enactment of the new Colorado law early last year, decisions reached in a controversy over a hail suppression project in the San Luis Valley point up some of the subtle policy issues involved in weather modification regulation.

Weather modification as a contemporary technology goes back to the discovery, made in the 1940's, that precipitation can be induced from supercooled clouds by seeding them with Dry Ice (later, silver iodide particles would be preferred). The possibility of rainmaking through cloud seeding aroused early interest in the arid West, including Colorado and other states of the High Plains region that extends from Montana and the Dakotas down to Oklahoma and Texas.

Indeed, with the onset of the severe High Plains drought of the 1950's, many farmers in this parched region welcomed commercial cloud seeders with enthusiasm. Although skepticism set in when the results of the cloud seeding proved uncertain and often disappointing, some interest in weather modification remained even after the drought eased. The San Luis Valley of southern Colorado is one place where this was true. This valley, flanked by the La Garita Mountains and Cochetopa Hills on the west, and the Sangre de Cristo and Culebra mountains on the east and north, is a region more arid even than the High Plains. Precipitation in the valley averages 6.5 inches a year, compared to Denver's 14 inches.

Moreover, in summer when there is precipitation in the valley, it may come in a most unwelcome form—big hailstones that leave crops severely damaged or ruined. And, for growers of Moravian barley, an important cash crop in the valley, there is a 6-week ripening and harvest period in late summer when even a heavy rain may represent hard luck. If too much dampened, the barley is rendered unfit for malting with rice to make beer and is thus unacceptable to the Adolph Coors Company of Golden, Colorado, the brewery that has been buying all of the Moravian barley crop.

Some 7 years ago, William K. Coors, president of the Coors Company, initiated a program of weather modification for the valley aimed at suppressing hail and diverting rainfall during the critical late-summer period. As it happens, however, the 380 barley growers in the five-county San Luis Valley area are outnumbered by people in other agricultural pursuits, especially ranchers, who are less concerned about hail than they are about drought. It is therefore not surprising that the weather modification project was to become controversial. In 1969, when the project was in its third year, the valley received more rainfall than usual. But 1970 turned out to be unusually dry, and many farmers suspected the cloud seeding of causing the lack of summer rain. In August of that year, some 400 ranchers and farmers formed a group called the San Luis Citizens Concerned about Weather Modification (later to call itself the Citizens for the Preservation of Natural Resources).

By 1971, although it was far from clear what effect the cloud seeding project had produced, many valley people were demanding that the project be stopped. The fact that some of the allegations giving rise to this de-

mand were farfetched made them no less troublesome for the project's sponsors. For instance, if a rancher's well went dry, the true explanation probably lay in years of overpumping, but the charge that the weather modifiers were to blame nevertheless enjoyed wide credibility in the valley.

A valley delegation met with Governor John Love to protest the cloud seeding, only to learn that he had no authority to stop the project. Under the then-existing law, weather modifiers had to obtain a license to operate in Colorado, but, with the license once in hand, there was no requirement to obtain permits project by project. Although taking no position on the San Luis Valley cloud seeding, the governor said he would support legislation giving the state greater regulatory authority. State Representative Clarence Quinlan, a powerful Republican legislator from the valley and a big rancher himself, thereupon began preparing a weather modification control bill.

That relatively little had been done about regulating weather modification in Colorado and most other states up to that time could be explained partly by the fact that commercial cloud seeding has never been a large activity. There are today not more than about eight well-established commercial weather modification companies in this country. Altogether, these companies are said to do only $2 to $3 million worth of domestic business a year, and part of this is in flying cloud seeding missions in connection with federally sponsored research. (The Weather Modification Association is made up of about 150 persons, including most of the commercial weather modifiers, some meteorologists at universities, and some people associated with farm groups, water districts, and state and federal agencies. The association appears to be a relatively small fraternity in which almost everybody knows everybody else.)

The very modest volume of commercial work reflects the fact that only two weather modification activities are accepted as proved operational technologies. Cloud seeding has definitely been shown to increase snowfall significantly along the crests of the Rockies or the Sierra Nevada; this results in more spring runoff to fill reservoirs, turn hydropower turbines, and irrigate croplands. The other operational technology is in the dispersal of cold (below freezing) fog from airports.

If, on the other hand, a menacing cloud is seeded for purposes of hail suppression and no hailstorm occurs, this may or may not mean that the seeding was responsible. And, should there be a hailstorm, the possibility that the seeding caused it cannot always be discounted. Major uncertainties also still attend attempts at rainmaking. Weather modifiers are pleased to receive credit when the weather is behaving as desired, but, should a destructive or unwanted storm bring a lawsuit, they readily (and thus far successfully) take refuge in the absence of scientific proof of causality.

Except for a requirement to file reports on their activities with the National Oceanic and Atmospheric Administration, weather modifiers are under no federal regulation. Across the nation, state regulation seems to vary from the unduly permissive to the unrealistically severe. In certain states in the East, notably West Virginia and Pennsylvania, the current regulations are demanding to a point that weather modifiers cannot operate under them. Regulation in the arid states of the West, where weather modification finds its greatest potential, has generally (although not always) been minimal and permissive, in the old Colorado manner.

Representative Quinlan found that sentiment in Colorado about weather modification was sufficiently mixed that, if he were to have the legislature enact a meaningful regulatory bill, his approach would have to be more or less evenhanded. Whatever some of Quinlan's constituents in the San Luis Valley might want, weather modification activities were not going to be banned. Renewed interest in this field was being stimulated by the U.S. Bureau of Reclamation's research and pilot projects directed at increasing the snowpack in the Rockies and at rainmaking on the High Plains. Also, the National Center for Atmospheric Research (NCAR) at Boulder, which is funded by the National Science Foundation, was beginning a 5-year, $15-million hail research experiment in northeastern Colorado's "hail alley."

The weather modification control bill enacted by the Colorado legislature in early 1972 under Quinlan's leader-

## Federal Control of the Rainmakers?

Besides giving rise to a precedent-setting state regulatory decision, the San Luis Valley cloud seeding controversy also has inspired proposed legislation to bring weather modification under comprehensive federal regulation.

H.R. 4770, introduced on 27 February by Representative Frank Evans (D–Colo.), would make it necessary for commercial weather modifiers to obtain a federal as well as state permit before a cloud seeding project could be undertaken. Evans's interest in weather modification regulation first developed after he began hearing from constituents in the San Luis Valley. In introducing the bill, he observed: "There is comparatively little protection for the citizen who does not want his individual rights to natural weather infringed upon. . . . I believe the time has come when we must recognize the perils [of weather modification] as well as the benefits."

In its present form, the Evans bill would present many difficulties for commercial weather modifiers. In addition to obtaining licenses and permits at both the state and federal levels, they would have to satisfy extensive reporting requirements and, at least in some situations, furnish a bond of up to $1 million (weather modifiers customarily carry insurance against the possibility of successful damage claims). The regulatory program would be administered by the National Oceanic and Atmospheric Administration of the Department of Commerce.

According to an aide, Evans does not view H.R. 4770 as a finished piece of legislation, but rather as one to be improved through hearings and committee consideration. At the moment, however, the bill is going nowhere. Nixon Administration officials feel that thinking about comprehensive federal regulation is premature because interstate problems are yet to arise. No committee hearings on the bill have been scheduled and none seem in prospect, at least not this year.—L.J.C.

ship had been shrewdly designed to reflect all the political interests at play. For the San Luis Valley ranchers upset about cloud seeding, there was the promise of tight regulation of the weather modifiers. Specifically, the cloud seeder hired by Valley Growers, Inc., the barley growers association now sponsoring the hail suppression project, would have to seek a permit and justify the project at a public hearing.

Yet, for those in the San Luis Valley and elsewhere who believed in cloud seeding, or at least favored continued experimentation, the new law declared weather modification to be economically beneficial and worthy of encouragement. Furthermore, under the law, the governor would appoint a ten-member advisory committee made up half of persons technically qualified in weather modification or related fields and half of ranchers and farmers from various parts of Colorado.

The permit hearing held one evening last July for the 1972 San Luis Valley hail suppression project was attended by some 600 persons and lasted until 2 o'clock the next morning. Plenty of passionate feeling was expressed about the project, both pro and con, but the majority sentiment was clearly one of opposition, with some people even suggesting that to tamper with God's weather is a sin.

The hearing officer ultimately recommended that the permit be denied. Although he questioned whether the project met the law's requirements for a showing of economic benefit, his recommendation was actually based on certain technicalities, including the applicant's failure to give proper legal notice of the hearing. For its part, the Weather Modification Advisory Committee put technicalities aside and recommended that the permit be issued, but with the stipulation that the project plan not include the suppression of rain as well as hail.

The director of the Colorado Department of Natural Resources, Thomas W. Ten Eyck, the official with the final say-so, went along with the advisory committee and granted the permit in the form recommended. Those who had opposed the permit took little comfort in the stipulation against rain suppression, however. Just how much the project was resented became evident in August when, one moonlit night, someone sneaked up to a trailer used by Atmospherics, Inc., the Fresno, California, firm that had been awarded the cloud seeding contract, and tossed a bomb through a window, doing $10,000 worth of damage to cloud tracking equipment.

The next major development in the campaign to stop the cloud seeding came last 7 November when an advisory referendum was held in the San Luis Valley counties. In four of the five valley counties, the county commissioners, acting at the request of Citizens for the Preservation of Natural Resources (the new group opposing cloud seeding), had this question put on the ballot: "Do you favor the modification of weather and natural precipitation by cloud seeding or other artificial means within the boundaries of your county?" In the fifth county, Rio Grande, where most of the barley is grown, the question began, "Are you opposed to . . . ?" but this difference in wording made little or no difference in the outcome. The vote went heavily against weather modification throughout the valley (10,281 to 2,553) and in not a single precinct was the vote favorable to it.

### An Economic Blow

Shortly thereafter, William Coors, in a letter to each of the barley growers, informed them that, if no weather modification program were conducted in 1973 and later years, his company would all but eliminate its purchases of barley from the valley, beginning with a 20 percent cut the first year. Inasmuch as the Coors Company had paid valley growers some $7.4 million for their 1972 crop, the phasing out of barley purchases in the future would hurt not only the growers but the valley economy as a whole.

Early this past March, 3 days of hearings were held at Alamosa, in the valley, on the application by Atmospherics, Inc., for its 1973 project. Atmospherics came with five lawyers, a battery of expert witnesses, and, many felt, a weak case. The opposition was represented by Carlos F. Lucero, an Alamosa attorney retained by Citizens for the Preservation of Natural Resources.

One of Lucero's witnesses, Charles B. Moore, a professor of atmospheric physics from the New Mexico Institute of Mining and Technology, testified that the proposed hail suppression program probably would not increase precipitation as was now claimed but would actually decrease it. In his opinion, seeding the cumulus clouds in the manner proposed would produce tiny ice crystals that would blow away or evaporate before ever reaching the ground. However, there was no conclusive evidence presented by any witness, on either side, of past cloud seeding having caused either a seasonal increase or decrease in rainfall.

As Lucero pointed out, there was no little irony in the support given Atmospherics and Valley Growers, Inc., by two expert witnesses from South Dakota, Richard S. Schleusener, director of the Institute of Atmospheric Sciences at the South Dakota School of Mines and Technology, and Merlin C. Williams, director of the South Dakota Weather Control Commission. Schleusener is an investigator in the NCAR Hail Research Experiment, a project justified on the very proposition that no one yet really knows whether hail suppression works or not. His institute also has been carrying on Project Cloud Catcher, a $675,000 experiment sponsored by the Bureau of Reclamation which has been criticized because, under this project, some of the storm clouds that caused last June's devastating Rapid City flood had been seeded. Meteorologists familiar with the storm, which caused $100 million worth of property losses and nearly 250 deaths, believe that the seeding could not have caused it nor contributed more than marginally to its intensity. Nevertheless, the coincidence was unfortunate, and, at the very least, shows weather modifiers to be capable of embarrassing naiveté.

As for Merlin Williams, his new agency is carrying out in much of South Dakota a hail suppression and rainmaking program oriented primarily to operational rather than research objectives (the program involves no randomization in the clouds seeded, and its research aims are clearly subordinate). This is a cooperative state-county program, with no county being included until after positive action by its elected board of commissioners. Of South Dakota's 67 counties, 42 thus far have chosen to take part, while 25 have not.

Yet here was Williams down in Colorado, supporting cloud seeding in a valley where the people had voted 4 to 1 against it. This he seems to have done largely as a favor to Thomas Henderson, the president of Atmospherics, which also does cloud seeding in the South Dakota program. Williams now, however, frankly questions the decision by Atmospherics and Valley Growers, Inc., to press the permit application in the face of the referendum results.

The upshot of the second round of

permit proceedings was that the hearing officer again recommended against the cloud seeding, and, this time, the advisory committee concurred in the recommendation and the Natural Resources director, Ten Eyck, denied the permit. At bottom, the outcome had been determined by two major considerations: First, despite all the testimony of experts, the effects of cloud seeding simply are not predictable. Second, last November's straw vote showed conclusively that people in the San Luis Valley wanted the weather modification project stopped.

Under the new Colorado law, the applicant was required to show, among other things, that his proposed project (i) is technically feasible; (ii) involves no high risk of harming people, property, or the general environment; and (iii) is of economic benefit to the San Luis Valley and to Colorado. In his written opinion, Joseph Cook, the hearing officer, concluded that Atmospherics met the test on the first two, but not on the third. "The best judges of whether the people in the area are benefited are the people themselves," Cook said, referring to the straw vote.

On the other hand, the chairman of the advisory committee, Lewis O. Grant of Colorado State University (the meteorologist who demonstrated that the snowpack in the Rockies can be increased through cloud seeding), told *Science* that the straw vote was not decisive in his group's thinking. What was decisive, he believes, was the insufficiency of the information presented in support of the weather modification plan. Ten Eyck also found the applicant's case insufficient, but he says his judgment was strongly influenced by the outcome of the referendum.

In essence, the controversy over the San Luis Valley cloud seeding has posed two key policy questions:

- Should the state be allowing a purely commercial and *operational* (as opposed to experimental) weather modification project that involves the use of unproved methods having unpredictable effects?
- If the answer to the above is Yes, should it be qualified by adding that such a project must have the consent of a majority of the people in the area directly affected?

Although these questions were addressed somewhat obliquely in the San Luis Valley case, they were indeed addressed, with the answers being Yes to both questions. Therefore, barring an unlikely reversal of Ten Eyck's decision by the Colorado courts (as now sought by Atmospherics and Valley Growers, Inc.), the decision will stand as an important precedent. (It now appears that, even for the barley growers, the practical consequences of the decision will not be quite as bad as it first seemed when the Coors Company announced that most of its barley purchases in the valley would be phased out if the weather modification program were not continued. Coors is in fact carrying through with the cutback of purchases. But buyers for another brewery, who are not convinced that cloud seeding makes any difference, are now beginning to place contracts for barley with valley growers.)

Ten Eyck and his advisers are taking a clearly positive attitude toward weather modification projects that have an experimental emphasis. Already, permits have been granted for three such projects: the NCAR hail research project and two projects on increasing the snowpack in the Rockies (in one of the latter, the Bureau of Reclamation had redrawn the "target area" to exclude Ouray County because two small towns there want no more snow than nature alone provides).

Ten Eyck indicates that the San Luis Valley cloud seeding project would be more favorably regarded by him and his advisory committee if designed more as an experiment, with some randomization in the selection of clouds for seeding. The cost of a properly instrumented cloud seeding experiment would no doubt be well beyond the barley growers, however, even if, despite the high feeling in the San Luis Valley against *any* weather modification, a permit were indeed granted.

—LUTHER J. CARTER

# Herbicide Panel Short on Fieldwork

The national controversy that has grown up about the impact of U.S. defoliation in Vietnam may be still far from settled after the report of the National Academy of Sciences' Committee on the Effects of Herbicides in Vietnam is released this fall. Last week, committee members working up the final document were admitting that they were unable to make the field studies in Vietnam on the scale and depth they had planned in view of the military situation there, and that the results would be less definitive than had been anticipated in 1970 when Congress assigned them the job of making a thorough study. The study has cost $1.25 million.

Even in March 1972, the committee interim report stated boldly: "It will be impossible to reach meaningful conclusions from random ground checks and qualitative aerial observations." But last week, committee chairman Anton Lang of Michigan State University and its executive director, Philip Ross, admitted in interviews that the security and logistics problems in the countryside had "hampered" or "impaired" systematic work on the ground. Lang said, "Since we did not do as much ground work as we expected, we have made extensive use of aerial photography and other means." Frank Golley, a committee member and executive director of the University of Georgia Institute of Ecology, said: "The committee did the best work possible under the circumstances, but it will not be the definitive study we had hoped it would be. We just couldn't get into the field to do the work because we would have been shot at." He said that they had resorted to aerial photographs, field trials outside Vietnam, and reading as alternative methods of study.

On 31 August the committee plans to give its final report to the Secretary of Defense, who in turn must release it unchanged in 30 days. The report will contain some field data, but some of it will have been gathered on a "hit or miss" basis, as one member said. Its approach will differ, then, from the ambitious program of quantitative analyses of various forest types, of the different agents and various times of application, of the cultural and psychological impact of the herbicide program, and, finally, of the sensitive issue of the persistence of the chemicals—including the known teratogen dioxin found in Agent Orange—in the Vietnamese environment, outlined in the 1972 interim report.

Not until the text of the report is made public will it be known how successfully the committee circumvented the problem of having "hit or miss" field data to work from. But at present it looks as though their report might leave some questions, anyway, unanswered.—D.S.