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HAIL AS SUDDEN DISASTER: PUBLIC RESPONSE TO HAIL SUPPRESSION ACTIVITY*

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INTRODUCTION

Farmers in northeastern Colorado refer to hail as "sudden poverty." This is understandable since they live on the lee side of the Rockies where catastrophic hailstorms can mean the difference between survival and nonsurvival on the land. Here, and in other parts of the United States, hail causes millions of dollars in losses every year with the concomitant social consequences stemming from catastrophic loss.

In this paper we will examine briefly the severity of the hail hazard in the United States, its geographical distribution, and some possible adjustments to hail that have been or could be attempted. The remainder of the paper will focus on one of these adjustments – hail suppression. Projects in the Blue Ridge area, the San Luis Valley of Colorado, and in South Dakota will be reviewed briefly with the focus on public response to them. These case studies reveal how societal processes may affect the application of a technology toward the reduction of a hazard.

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THE SEVERITY OF THE HAIL HAZARD IN THE UNITED STATES

Economic losses from hail are usually divided into two categories: crop loss and property loss. Annual crop loss in the United States is estimated to be from $600 to $700 million (2% of crop value) and property loss from $76 to $150 million (White and Haas, 1975; Friedman, 1976; *Science*, 1976). Not only is 2% of the United States crop directly lost annually through hail, but secondary losses (decreases in economic activity related to grain elevators, the transportation industry, and the like) are also incurred (Changnon, 1976). The social consequences of sudden and extensive hail are not well understood at present. While hail is virtually never responsible for human death, it does cause disruption in the form of economic nonviability of farm families, foreclosures, and the like. Social impacts of hail must not be ignored in our consideration of the seriousness of the hail hazard.

Hail is a sporadic climatological phenomenon, occurring seemingly without a spatial pattern. On any given day during the hail season (April to September), damaging hail occurs at widely

scattered points across the nation. The ten leading crop hail damage states are Illinois, Texas, Iowa, Nebraska, Minnesota, Kansas, North Dakota, North Carolina, South Dakota and Colorado (Changnon, 1976). Hail is an increasingly important natural hazard with trends toward a worsening situation.

POSSIBLE ADJUSTMENTS TO HAIL

Several alternative responses to the problem of hail in the United States exist (Brinkmann, 1975). Potential adjustment mechanisms include: (1) modification of the environment, (2) modification of human behavior, and (3) modification of the weather.

With regard to modification of the environment, Brinkmann considered the possibility of farmers growing crops less subject to heavy hail damage in certain areas of the country where high hail damage occurs. She concluded, however, that neither alteration of prevailing cropping patterns nor development of new hail-resistant strains of plants offered much promise.

Improved forecasting would fall under modification of human behavior. But Brinkmann concluded that, "in general an improved hail forecast warning system would not be very effective in significantly reducing damages" (p. 82). Even with perfect forecasting, there is little a farmer can do to prevent the crop from being damaged. However, forecasting in juxtaposition with effective hail suppression could prove to be significant in the prevention of damaging hail.

For the individual farmer scattered (noncontiguous) land holdings could protect him from catastrophic loss given any discrete hailstorm situation but this approach cannot protect the nation from the loss of the crop. Over 80% of the nation's crop value is not insured for hail loss (Brinkmann, 1975). Furthermore, the pattern of insurance purchasing is such that farmers in high-risk areas are much less likely to buy insurance than others (p. 85). In 1969 about 20% of the hail losses experienced were recompensed either by commercial stock and mutual companies or the Federal Crop Insurance Corporation. Apparently hail insurance premiums are perceived to be too high for most farmers to utilize insurance in a widespread fashion. Federal emergency assistance to farmers is available when an area is declared a major disaster area by the President but damage from hail alone is generally not sufficent to warrant a presidential disaster declaration.

Hail suppression through cloud seeding has been identified as the potentially most promising area for future research regarding the hail hazard (White and Haas, 1975). Although there has been some optimism in the scientific community about the prospects of a technology to reduce damaging hail, and although commercial cloud seeders have carried out operational hail suppression programs in various parts of the country, hail suppression is still a matter of scientific uncertainty (*Science*, 1976). Some positive empirical results have been reported in the literature (Changnon, 1976), but none have achieved a level of statistical significance accepted by most scientists establishing that damaging hail at the ground has been reduced by silver iodide seeding. In fact, the randomized experiment underway in northeastern Colorado, the National Hail Research Experiment (NHRE), has, to date, found no statistically significant reduction of hail as a result of cloud seeding. There remains a possibility that seeding has actually increased hail from some of the storms. Therefore, the current "state of the art" in hail suppression is a matter of scientific controversy. Even so, during the last 15 years, some 60 hail suppression projects have been carried out in the United States – about two-thirds of them for operational and one-third for experimental purposes. Public experience with hail suppression technology is thus quite limited, although hail suppression projects have been carried out in Colorado, Kansas, Nebraska, North Dakota, South Dakota, Texas, and elsewhere. Several of these projects have generated

increased public interest, at times quite intense. We turn now to a consideration of several cases where hail suppression has been applied.

PUBLIC RESPONSE TO HAIL SUPPRESSION PROJECTS

The sociological aspects of weather modification have been studied since the late 1960s; two longitudinal surveys of populations experiencing hail suppression have been taken in northeastern Colorado (Haas and Pfost, 1972; Haas and Krane, 1973a, 1973b; Krane, 1975) and in South Dakota (Farhar and Krane, 1973; Farhar and Mewes, 1974, 1976). Other projects have been monitored by social scientists studying acceptance/rejection processes. Hail suppression has been accepted in northeastern Colorado, Kansas, and North Dakota; it has been the focus of controversy and organized opposition in the San Luis Valley of Colorado, the Texas panhandle, South Dakota, and the Blue Ridge area. Opponents in these local areas have felt that hail suppression resulted in reduced rainfall, or that it did not effectively decrease hail (Farhar, 1976; Mewes, 1976).

Selected for discussion here are three cases, representing areas where hail suppression has become a controversial issue. The three cases, the Blue Ridge case, the San Luis Valley case, and the South Dakota case, involved *operational* (not experimental) cloud seeding. Several important factors concerning social response to hail suppression are highlighted by these cases. First, each case involved heterogeneity of weather needs. That is, within the project area, some crops at certain periods of time benefit from additional rainfall while others would suffer damage from rainfall at that time. Range or pasture may benefit from moisture deposited by hail, while crops would be hail-damaged. Heterogeneity of weather needs is the basis for system-level conflicts of interest with regard to planned intervention in weather processes.

Second, in each case a drought or dry weather conditions developed while cloud seeding was implemented. Opponents were inclined to attribute such conditions to cloud seeding for hail suppression. Those conducting the cloud seeding deny these allegations, stating that, if anything, seeding for hail suppression should increase rainfall in the target area.

Third, each project was carried out in a context of scientific dissensus about the readiness of hail suppression for operational application. Adoption of hail suppression requires a collective decision on a scientifically uncertain technology. The uncertainty implies that a degree of risk is involved (the degree may be quite limited, but may be said to exist); in general, risk-takers prefer to adopt their own risks, rather than have such decisions made for them.

Fourth, the degree of public participation in the adoption decision varied in the three cases. In Colorado and the Blue Ridge Area, voluntary associations of agriculturists (irrigating farmers in both cases) raised funds and contracted for hail suppression with a weather modification firm. In South Dakota, the adoption decision was made at the county level by county commissioners. It is probable that the degree of participation for residents as a whole in the adoption decision in all three areas was not high.

Fifth, it is noteworthy that in all cases, adoption occurred in high hail loss areas – areas where hail destroys up to 20% of the crop. Willingness to adopt an uncertain technology – one perceived as potentially ameliorative and possessing a low probability of causing damage – is clearly enhanced in areas where hail is a serious problem.

Sixth, in all three cases, the credibility of those supporting and running the programs was called into question by opponents resulting in a polarized community situation. Arguments raged over both the technology's effectiveness and how decisions were made to adopt it. Organized opposition emerged in the three cases; in all three the opposition groups were successful in halting the projects.

Hail Suppression in the Blue Ridge Area

In the summer of 1956, in response to severe hail damage to fruit orchards in the Blue Ridge area (which included portions of West Virginia, Maryland, Pennsylvania and Virginia), a group of orchardists incorporated a nonprofit organization called the Blue Ridge Weather Modification Association. This group contracted with a commercial cloud seeding firm to conduct an operational hail suppression program from May to August 1957 supported by voluntary contributions.

Besides fruit crops, dairy farming was the other major economic interest in the area where cloud seeding was conducted. There is some evidence to suggest that the orchardists who were relatively well-off had strained relations with the dairy farmers who were somewhat less prosperous. The dairy farmers relied on pasture land tending to benefit from hail moisture, while fruit crops can be quickly ruined by hail.

As events unfolded the first operational year, was extremely dry in and around the target area. The belief began to develop that cloud seeding was suppressing clouds capable of producing rainfall in order to eliminate the danger of hail. Letters to the editor opposing the cloud seeding began to appear in the local newspapers and the topic came up in discussions at local organizational meetings. However, from 1958 through 1961 adequate rainfall was experienced in the general area while the hail suppression project continued. During this period, opposition was largely forgotten, suggesting a link between the formation of opposition and the existence of local economic hardship caused by negative weather.

In 1962, however, a drought reoccurred, and the opposition intensified (Howell, 1965a). Respondents in our study have alleged that program sponsors were the recipients of anonymous threats, acts of vandalism (such as the destruction of fruit trees and poisoning of farm ponds), and other harrassment. Several groups opposing the "weather tampering" organized.

The summer of 1964 saw an extremely dry period in the entire northeastern United States, so that the issue of rainfall became central, even though the weather modifier claimed he was increasing rainfall in the project area by 14% (Howell, 1965b).

A number of public meetings provided forums for arguments against intervention in natural weather processes and for farmers' rights to experience weather in its natural form. A number of townships passed local ordinances banning cloud seeding activities within their jurisdictions. A generator operator was arrested, tried, and convicted of violating such an ordinance (Davis, 1974).

At about the same time, an injunction was sought against the hail suppression project by an opponent group. The injunction was denied, but state statutes effectively discouraged cloud seeding in the area and none has been carried out since 1969 to our knowledge.

Nevertheless, opponents have continued to believe that cloud seeding has been carried on in the Blue Ridge area. In 1968 the Tri-State Natural Weather Association was organized. The Tri-State group vetoed violent activity as a matter of policy, and has instead focused its attention on political, legal and public information efforts against cloud seeding. The organization has produced a number of brochures which have been made available not only locally but to opponents in other parts of the United States (Tri-State Natural Weather Association, n.d.; Kinter, 1970).

From the Tri-State group's point of view, there is a conspiracy of private and public interests to carry out cloud seeding to help ensure dry weather conditions. The failure of official investigations to uncover any illegal cloud seeding activity has not been convincing to the opposition. Today, a decade later, the Tri-State Weather Association is still active in spreading its message about the dangers of cloud seeding to other opponents throughout the country with whom they come in contact.

San Luis Valley, Colorado

In a normal climate of scanty annual rainfall (6.5 inches) and relatively frequent occurrence of damaging hail, cloud seeding was introduced for a short time in the San Luis Valley. Opposition soon developed on the basis that "abnormal weather" was occurring, primarily drought. Subsequently, lettuce growers financed a hail program for two years, but sponsors felt that the program was too expensive to maintain.

In 1967, a weather modifier persuaded the Coors Brewing Company of Golden, Colorado, that a weather modification program could aid the brewing barley crop grown in the San Luis Valley. Since hail (or moisture in any form) is particularly damaging to barley during its ripening stages, the brewery was interested in what could be done to protect the crop. A project was implemented in 1969 with three purposes: first, to increase precipitation during the growing season; second, to decrease precipitation at harvest time when moisture could damage the ripening barley; and third, to suppress hail throughout the growing season. Thus the weather modifier himself agreed to decrease rainfall, a potent source of opposition in an area where 75% of the local economy was dependent on ranching. The modifier apparently claimed that it was within his technical ability to control a variety of severe storm situations, including tornadoes, hail, high winds, and heavy rains (Flavin, 1971).

Not long after, an independent insurance company was formed to insure against hail damage and fund hail suppression. But after two years, the insurance company ceased to exist after extensive claims for hail damage. Subsequently, Coors informed the barley growers that they were to be responsible for the support of continuing a hail suppression program, a prerequisite for Coors' continued purchasing of valley barley.

During the period the weather modification operations were underway, the entire Southwest was experiencing a drought which became more severe during 1971. The underground water table dropped resulting in a critical effect on range plants whose roots could reach the water table under normal conditions and who were now beginning to die. During this time ranchers experienced excessive problems in pasturing cattle.

The economy of the Valley was far more dependent on ranching than it was on the barley or lettuce crops grown there. Ranchers were more dependent on natural precipitation than were the irrigating barley growers, and this heterogeneity of weather needs was basic to the entire course of events in the Valley. In addition, there were many Valley residents who were either skeptical about the efficacy of cloud seeding to produce beneficial results or who were opposed to any intervention whatsoever in natural weather processes.

Ranchers and timber interests in the valley and on its periphery had not been included in the weather modification decision process. These important local interest groups felt they were being economically damaged by the cloud seeding operations, and that they had had no means of making their position effectively felt in connection with the cloud seeding project.

An opponent group, organized in 1970, affected the choice of a new firm to carry out the cloud seeding. But other opponents were still not satisfied and a new opposition group formed in 1972. Its president was a rancher from an old-line Valley family.

There had been debate among the weather modifiers involved in the cloud seeding program over the years about the project's purposes and the technical capability to carry them out. The controversy was reported in the local media and citizens of the area became aware that meteorologists were not necessarily in agreement about the state of the art.

In 1972, opponents in the valley were influential in getting legislation passed regulating weather modification in Colorado. The law provided for public hearings in the project area

prior to the granting of project permits. The first such hearing was held in the Valley on July 31, 1972, with about 600 in attendance. Subsequently, a permit was approved and two weeks later a trailer containing project equipment was dynamited, causing about $50,000 damage. Although state and local authorities investigated the incident, no one was ever arrested for the bombing.

The following March, a second public hearing on the permit for the 1973 season was attended by about 300 persons. The strongest ammunition the opponents had was the result of a straw vote taken the previous November during the general election. Ballots from a five-county straw vote had resulted in an overwhelming negative response: citizens voted against weather modification four to one.

Even though the vote had no legally binding power, it was cited by officials as the major reason for not granting the permit for the 1973 season. Upon appeal, the decision was upheld in court. No further summertime weather modification has been conducted in the valley despite threats by the Coors Company to decrease the amount of barley purchased there by 10% each season that weather modification was not conducted.

Hail Suppression in South Dakota

In South Dakota, citizen interest in cloud seeding to ameliorate weather conditions has a history dating back to the early fifties when weather modification was being carried out in a third of the state's counties. There is no record of any active opposition to the research projects which spanned more than a decade, culminating in the initiation of a statewide cloud seeding program in the spring of 1972. The legislature appropriated funds for the development of the program, called the South Dakota Weather Modification Program (SDWMP). Between 1972 and 1975, funding increased from a quarter of a million dollars to about a million dollars. The number of counties involved increased from 26 to 47 during that interval. The conviction that county government should decide county participation in the program originated at the state level from the outset. The purpose of the SDWMP was to suppress hail and increase rainfall, with hail suppression having operational priority. The county provided 25% of the cost of operation through mill levy taxes and the state contributed 75% from the general fund.

Our research group has monitored public response to the SDWMP since before the program's initial operations (Haas, 1973). A longitudinal survey of a random citizen sample in 20 participating counties was conducted over four time periods between 1972 and 1974. Some of the results of the survey and monitoring efforts are as follows (Farhar and Mewes, 1976). Prior to the beginning of the SDWMP the survey showed majority favorability to the idea of modifying the weather for the benefit of agriculture in participating counties. Between the first and second waves of survey interviewing, the Rapid City flood occurred in a period of cloud seeding on June 9, 1972. An official report on the flood stated that cloud seeding did not contribute materially to the flood occurrence. Most respondents when interviewed in the fall of 1972 did not attribute the flood to cloud seeding. Also, by that time, respondents were more convinced than they had been earlier that cloud seeding could actually increase rainfall and decrease hail. But, by the September 1974 interview, belief that cloud seeding could actually increase rainfall had fallen off somewhat and evaluation of cloud seeding was somewhat less favorable than it had been in earlier interviews.

Concern about side effects and the religio-natural orientation – the belief that weather processes should be left up to nature or God, free from human intervention – were the most important factors in determining respondent evaluation of cloud seeding prior to the SDWMP's inception. Over time, however, these concerns were replaced in importance by per-

ception of project effects themselves. Perceptions of cloud seeding's effectiveness and economic consequences became the most relevant factors in how projects were evaluated.

Throughout the survey the majority of respondents indicated their preference that the decision to participate in a cloud seeding program be made by or shared with local levels – the people to be affected by the program.

A policy of active information dissemination had been adopted by the Division of Weather Modification. But, levels of awareness about program activity in South Dakota remained low throughout the course of the study. The relationship between increased knowledge about weather modification and favorable evaluation appears to be one of no direct correlation. Those becoming more knowledgeable become more strongly opposed or more strongly favorable.

In fact, after three operational seasons, organized opposition to weather modification developed in South Dakota with the formation of a group called Citizens Against Cloud Seeding. The opposition formed in a context of overall public favorability (in the 20 participating counties) to the idea of modifying the weather, but it was initiated and supported at the grassroots level by farmers and ranchers in different locales who felt the program was damaging them economically. The major damage attributed to cloud seeding was drought.

Opposition activity continued through the 1975 operational season with public meetings, letters to the editor, television appearances, and circulation of petitions throughout many counties of the state. While the opposition did not emphasize the hail suppression component of the SDWMP, there were contentions that the cloud seeding either increased hail or failed to reduce it and that it reduced rainfall. The eyewitness accounts of "disintegrating clouds" were reminiscent of weather modification controversies in Texas and Colorado, where similar observations were reported by opponents to those programs. There was no reason to believe that opponents in South Dakota had been in contact with either the Texas or Colorado opponents prior to their own opposition effort. However, subsequent to their organization, Citizens Against Cloud Seeding, made contact with the San Luis Valley opposition and the Tri-State Natural Weather Association, forming an incipient national network of opposition groups. By the 1976 legislative session, opponents had made progress with members of the state legislature, and the Program's appropriation failed to achieve the requisite two-thirds majority for passage. Thus, the Division of Weather Modification ceased to exist on June 30, 1976, after four operational seasons.

Some members of the legislature felt that cloud seeding had become institutionalized somewhat too rapidly in South Dakota without adequate evaluation of the effects of seeding on precipitation and on downwind areas such as Minnesota. The power of a grassroots organized opposition in terms of halting projects has never been more convincingly demonstrated than it is in the South Dakota case. The outcome is of particular interest since local government participated in decision making relative to the cloud seeding project and, at least theoretically, the interest groups of the community should have been represented in the decision process. However, when the economic viability of farmers is threatened through drought, and vestiges of doubt remain about the efficacy of a weather modification program, the impetus for an organized opposition is startlingly high.

CONCLUSION

The cases discussed in this article display several parallels all the more notable since they occurred independently of each other. These include the presence of dry conditions harmful to important economic interests in communities, the probable exclusion of these interests in the adoption decision process, and lack of scientific

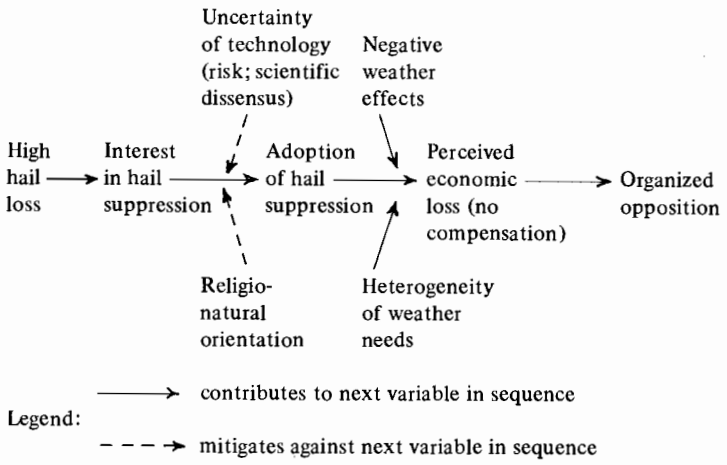

Fig. 1. Principal variables leading to organized opposition.

consensus on the operational readiness of a hail suppression technology. All cases were marked by organized opposition which led to community polarization, and the utilization of a variety of techniques to achieve ascendancy in the adversary struggle. Without exception, opponent wishes ultimately prevailed. At present, the only exception to this pattern is a hail suppression project in the Texas Panhandle continuing after five years of opposition effort.

A simplified model of the principal variables leading to organized opposition is presented in Fig. 1.

The attempt to reduce damaging hail through cloud seeding has stressful consequences of its own. The intentional intervention in potentially damaging weather processes shifts the responsibility for weather effects from being out of human control (acts of God, acts of nature) to being within human control. The boundaries of partial atmospheric control are not known, either scientifically or legally.

Application of an uncertain technology implies that a relatively unknown level of risk is experienced by recipients. If the economic effects of the weather are not beneficial during the period of application, recipients have come to feel that the risks involved are too great in comparison to the possibility of advantages that could accrue. Recipients are not limited to the sponsoring organization, but are members of the community-at-large. Adequate decision processes relative to the application of weather modification have not yet been developed.

The nation as a whole stands to benefit economically if crops and property could be protected from damaging hail. Farmers in high hail loss areas have already evidenced interest in adopting hail suppression if it could be accomplished without undesirable side effects.

But the adoption of hail suppression in its uncertain scientific status carries the potential for socially disruptive consequences, and the costs of the research and development necessary to achieve a reliable technology are high. In the end, the promise of hail suppression as an adjustment to the hail hazard is a value decision, one not easy to achieve given the complexities involved.

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