

## Weather Modification: Water—Three Cents per Acre-Foot?

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"... and the windows of the heaven were opened. And rain fell upon the earth . . . ."<sup>1</sup> Thus, God visited His flood upon man. It is with man's attempt to open and close the windows of the heavens that we are here concerned. Although far from perfect at this time, man's attempt at rainmaking is certainly not the least successful of his efforts to mirror his Maker.

For the period November 1, 1951, through April 15, 1952, John A. Battle, meteorologist for the Santa Ana River Weather Corporation and the San Diego County Weather Corporation, made the assertion that his rainmaking activities had added "about 20 per cent more rain" than would have naturally fallen in the target area of the Santa Ana River watershed and San Diego County.<sup>2</sup> In round figures, this was said to mean a total of 1,400,000 acre-feet of new water, for a cost of less than \$40,000. *This meant water for less than three cents per acre-foot!*

At about the same time, the staff of the Division of Water Resources of the California Department of Public Works made an *Economic Report on Possible Benefits of Weather Modification Operations*.<sup>3</sup> For study purposes a ten per cent increase in precipitation was selected as a "modest figure" to measure the "reasonable positive effect" of cloud-seeding.<sup>4</sup> Using the watershed of an irrigation district located in the east central portion of California, the staff study concluded that even such a modest increase in precipitation as that assumed would result in total annual economic benefits of approximately \$2,250,000 in revenues from newly-irrigated acreage, \$50,000 from sale of firm power, \$51,000 in added dry farm income, \$180,000 in increased yield from range land, and other substantial benefits not as readily susceptible of monetary evaluation.<sup>5</sup>

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<sup>1</sup> GENESIS 7:11-12.

<sup>2</sup> BATTLE, REPORT ON CLOUD-SEEDING EXPERIMENTS IN THE SAN DIEGO COUNTY AND THE SANTA ANA RIVER WATERSHED, NOVEMBER 1, 1951, THROUGH APRIL 15, 1952, at 3 (1952).

<sup>3</sup> CAL. WATER RESOURCES BD., BULL. NO. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA app. I (1955).

<sup>4</sup> *Id.* at 259. The most recent report on the subject states: "Commercial seeding operations during the fall, winter, and spring period on the orographic and West Coast project class augmented natural precipitation on the average by 14 per cent, and this increase was significant at the 0.01 probability level." THOM, AN EVALUATION OF A SERIES OF OROGRAPHIC CLOUD SEEDING OPERATIONS 60 (Advisory Committee on Weather Control, Technical Report No. 2, 1957). The Advisory Committee on Weather Control was created August 13, 1953. 67 STAT. 559 (1953), as amended, 15 U.S.C. § 311, note (Supp. IV, 1957).

The cost of rainmaking is relatively low.<sup>6</sup> With the great economic potential in sight, it seems clear that weather modification is an aspect of our society which will remain and grow, and therefore one with which we, as lawyers, can well become more familiar. As the techniques and methods of evaluation are perfected, the inevitable hour for litigating rights and liabilities arising from such activities draws nearer.<sup>7</sup>

## I

### WHAT IS WEATHER MODIFICATION?

Before considering the legal aspects of this new technique of water production, it behooves the lawyer to achieve a passing familiarity with certain basic principles of the science with which he must deal. Just as a familiarity with geology and hydrology is fundamental to an understanding of the law of ground water, so some basic knowledge of meteorology is essential to analysis of the law as it may apply to weather modification.

#### *A. Definition of Terms*

For purposes of present consideration the many and varied weather or storm "situations" are simplified<sup>8</sup> to include (a) the cold front, (b) the warm front, and (c) the air mass storm. These three types of storms are described separately because in all probability they will ultimately raise somewhat different legal problems and call for different analyses. At the risk of over-simplification, the following characteristics of each may be kept in mind.

Weather—storms, clouds, and precipitation—normally does not follow or recur in defined channels as is the case with surface waters, nor does it slowly and evenly disperse its physical benefits as is the case with underground basins.<sup>9</sup> Weather is fundamentally mobile and erratic. It is the re-

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<sup>6</sup> CAL. WATER RESOURCES BD., BULL. NO. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA app. I at 266-67 (1955).

<sup>7</sup> See note 2 *supra* and corresponding text. An estimate of one-half mill per acre per year for the Great Plains area has been given. SOUTH DAKOTA STATE COLLEGE, CLOUD SEEDING RESULTS IN SOUTH DAKOTA DURING THE SEEDING YEARS 1951-1954, at 1.

<sup>8</sup> There appear to be no reported appellate decisions directly involving weather modification, although there have been several cases in the trial courts. *Samples v. Irving P. Krick, Inc.*, Civil Nos. 6212, 6223, 6224, W.D. Okla. (1954); *Avery v. O'Dwyer*, 305 N.Y. 658, 112 N.E.2d 428 (1953) (awaiting trial on the merits); *Slutsky v. City of New York*, 197 Misc. 730, 97 N.Y.S.2d 238 (Sup. Ct. 1950); *Auvil Orchards Co. v. Weather Modification, Inc.*, No. 40544, Super. Ct. Wash. (1956). See discussion of cases in OPPENHEIMER, LEGAL SITUATION (Advisory Committee on Weather Control, Technical Report No. 6, 1957).

<sup>9</sup> The occluded front, for instance, produces a substantial portion of California's rainfall and it may have the characteristics of either a cold or a warm front, or both.

<sup>9</sup> A much better case can be made, however, for the analogy between airborne moisture and percolating waters than for airborne moisture and surface waters or underground streams. See analysis in opinion by Milnor E. Gleaves of the office of the Los Angeles County Counsel, published serially in the Los Angeles Daily Journal, March 29, 30, and 31, 1948.

sult of the movement and interplay of large, three-dimensional air masses. These air masses move and overrun one another in response to a myriad of physical factors, some incapable of accurate measurement. Local topography and surface characteristics are of extreme importance.

Thus, a strong, cold air mass may press against the edge of a warm, moist air mass, causing the latter to rise abruptly against the face of the onrushing cold air. At the point of collision of air masses a low pressure trough is normally created. The surface where such air masses meet is commonly known as a cold front. The rapid rising and cooling of the moist, warm air ahead of the cold front leads to the formation of clouds. Ultimately, if low enough temperatures are attained in the upper reaches of the resulting clouds, the conditions are present for the formation of drops of water large enough to fall and the commencement of the precipitation cycle. If the warm air mass rises sufficiently to reach freezing levels the violence of the storm is greatly increased.

The cold front, in cross section (Figure 1), is relatively steep and therefore has a comparatively narrow band of precipitation. It may be characterized by a so-called "squall line" of thunder-storms. This type of frontal movement is responsible for a large portion of the winter rainfall in California. Of course, throughout most of California the inland movement of any moist air mass over the mountains may lead to substantial precipitation, although the more violent storms are cold fronts.

The warm front, on the other hand, is created by the movement of a warm air mass over a slower moving cold air mass. A warm front may overrun the cold air mass ahead of it for hundreds of miles. (Figure 2). The cloud structure is generally the flat stratus type, which is considerably more

VERTICAL CROSS SECTIONS  
STORM FRONTS

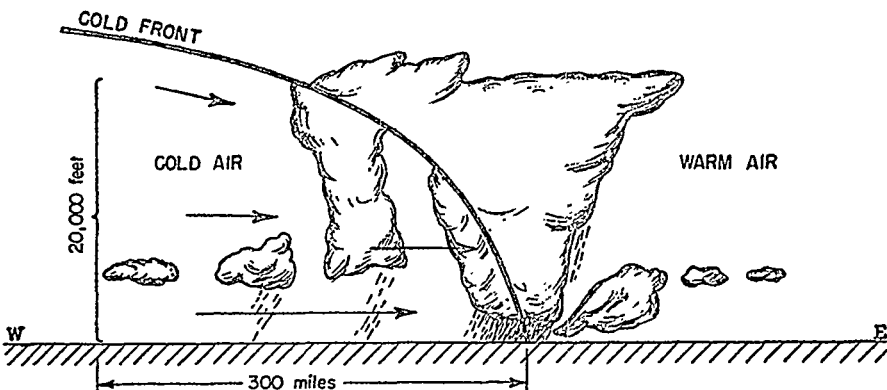


FIGURE 1

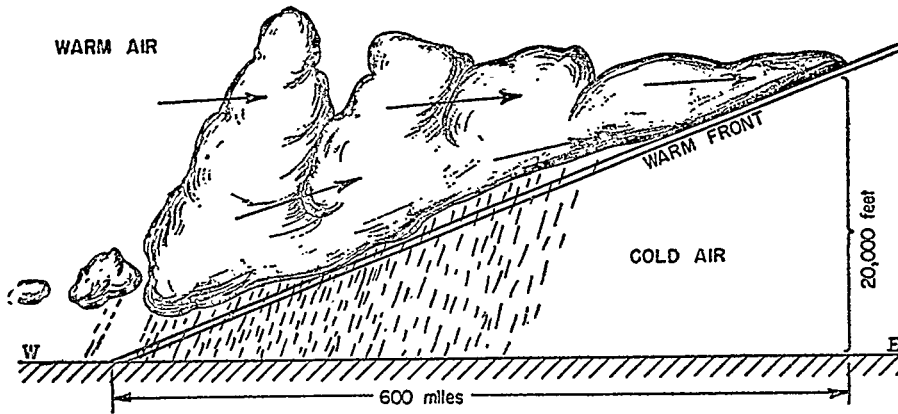


FIGURE 2

stable than that found in a cold front; rain from such storms is usually light. Present day seeding techniques are not particularly effective in warm fronts, although aerial seeding is sometimes possible.

Air mass storms, on the other hand, are essentially what we know as "thundershowers"; typical are those which occur during the summer time through the Southwest. They develop sporadically within a large air mass, rather than along its boundaries, as is the case with the frontal storm. Air mass storms are isolated; they are caused by strong downdrafts of cold air and the corresponding rapid rising of moist air. They are accentuated by the movement of surface winds over rising terrain or thermal lifting from the heated earth. Such storms are comparatively unrelated one to the other. They often result in heavy precipitation and hail in localized areas. Cloud-seeding can decrease precipitation from such storms; however, it is doubtful that cloud seeding can increase it.

Weather modification operations may be divided into two general categories insofar as legal significance of the work is concerned. First are the activities designed to increase precipitation—"rainmaking." A second and perhaps equally important field of weather modification is that of storm abatement, involving hail suppression and similar activities. Obviously, the legal problems and consequences of these two categories may differ considerably.

### *B. Physical Theory of Weather Modification*

The physical theory of weather modification is comparatively simple. The conditions necessary to turn a cloud into precipitation are (1) the existence of super-cooled water vapor, and (2) sufficient foreign nuclei around which such moisture can form to cause ice crystals or water droplets. The

freezing process and the condensation process give off heat, thus causing the air to rise; this leads to more condensation and the release of more heat. Small droplets of water adhere to the ice crystals until they have attained sufficient size to fall as precipitation. Precipitation thus commenced will continue until seeding is stopped or the nuclei are dispersed.

The problem of the rainmaker is to find clouds of sufficient size with proper temperature conditions in their upper layers. When this condition exists, the cloud may sometimes be "seeded" by inducing artificial nuclei into it. The basic method of "triggering" a cloud is to produce ice crystals or foreign nuclei around which ice crystals or water droplets can form. Although many agents might be developed for this work, the two most commonly used to date are (1) dry ice dropped into the cloud from an airplane to produce ice crystals and (2) silver iodide burned in ground generators and carried into the cloud in natural updrafts of air to provide foreign nuclei and some cooling.

If properly administered, artificial nucleation can trigger precipitation in a cloud or storm before it might otherwise have occurred in nature; alternatively, it may increase and intensify precipitation already commenced. On the other hand, if through accident or design a storm is overseeded, the effect can be to form so many ice crystals that they disperse the moisture in the freezing zone and thus destroy the basic conditions for precipitation. This is the process involved in hail dispersion.

### *C. Development of Modern Weather Modification*

The modern science of rainmaking commenced in 1947 with Project Cirrus, a cooperative research investigation in cloud physics sponsored by the Signal Corps and the Office of Naval Research, in consultation with General Electric Company, under the direction of Dr. Irving Langmuir and Dr. Vincent Schaefer. The results of Project Cirrus gave scientific credence to the mystic works of such pioneer rainmakers as California's now famous Charles Hatfield,<sup>10</sup> who for two decades at the beginning of this century carried on a single-handed campaign to moisten the arid Southwest.

Following publication of the results of Project Cirrus,<sup>11</sup> weather modification activities have been reported in many areas of the world and have extended not only to increasing rainfall, but to suppression of lightning, prevention of hail, and dispersion of fog. The relatively low cost of this

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<sup>10</sup> (Alias Burt Lancaster). Many modern meteorologists surmise that Mr. Hatfield may well have been close enough to the techniques now recognized by science, although there is no exact knowledge of the chemical used by him.

<sup>11</sup> Langmuir, *First Quarterly Report on Meteorological Research; Summary of Results Thus Far Obtained in Artificial Nucleation of Clouds*, REPORT NO. RL 140, PROJECT CIRRUS 11-18 (G. E. Co. Dec. 1948).

work invited commercial ingenuity<sup>12</sup> and excited the American imagination. One survey has indicated that during 1951, almost twenty per cent of the total area in the United States was the target for weather modification operations.<sup>13</sup>

As is normally the case, that which is commercially profitable and socially desirable soon attracted men of science, hard-headed business men, politicians, and even those who in another day would have been patent medicine salesmen. And as is the custom of our time, most of these pioneers and camp-followers at some point sought legal counsel.

The history and technical aspects of this new business, although referred to briefly here, are elsewhere better documented.<sup>14</sup> The purpose of this paper is to trace the parallel wanderings of legal minds on the subject.<sup>15</sup>

## II

### NATURE OF THE RIGHT, IF ANY, INVADED BY WEATHER MODIFICATION

What are the rights of the landowner or public body to natural rainfall? It has been suggested that the right to receive rainfall is one of those "natural rights" which is inherent in the full use of land from the fact of its natural contact with moisture in the air.<sup>16</sup>

In searching the common law antecedents of the concept of the riparian right to the natural flow of water we find language strikingly close to the problem at hand:<sup>17</sup>

The right to running water has always been properly described as a natural right, just like the right to the air we breathe; they are gifts of nature, and no one has a right to appropriate them.

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<sup>12</sup> "Between 1951 and 1953 Congressional hearings on several bills, introduced by members of both parties, revealed that farmers, ranchers, electric utilities, municipalities and other water users were paying 2 cents to 20 cents per acre, and annually were spending from \$3 million to \$5 million on weather modification operations." Oppenheimer, *Policy Considerations in Weather Modification*, STATE GOVERNMENT (May 1957) (Published by the Council of State Governments).

<sup>13</sup> CAL. WATER RESOURCES Bd., BULL. No. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA 14 (1955). This, notwithstanding that recent nuclei count studies have indicated that the Pacific Coast may be the only area in the United States where the air is sufficiently devoid of natural nuclei to make cloud-seeding for rain-increasing purposes of spectacular value. E.g., Schaefer, *The Concentration of Ice Nuclei in Air Passing the Summit of Mt. Washington*, 35 BULL. AMER. MET. SOC., No. 7 (1954).

<sup>14</sup> See bibliographical references and lists attached as apps. B and G to CAL. WATER RESOURCES Bd., BULL. No. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA (1955).

<sup>15</sup> Perhaps the two most thoughtful studies to date are those by Milnor E. Gleaves, note 9 *supra*, and Gavin M. Craig, *Legal Report on Liabilities Involved in Creation of Artificial Rainfall and Powers of the State to Regulate the Same*, CAL. WATER RESOURCES Bd., BULL. No. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA 213 (1955).

<sup>16</sup> *Id.* at 216.

<sup>17</sup> *Chasemore v. Richards*, 7 H.L. 349, 379, 11 Eng. Rep. 140, 152 (Ex. 1859).

And certainly the language of the court in *Hinman v. Pacific Air Transport*,<sup>18</sup> involving air travel, seems equally applicable here:<sup>19</sup>

Any use of such air or space by others which is injurious to his land, or which constitutes an actual interference with his possession or his beneficial use thereof, would be a trespass for which he would have remedy.

The rights of the landowner to the adjacent air space, the clouds therein, and the precipitation therefrom is not based upon absolute ownership but rather is a right not to have the air space used to his detriment. The supply of water in the overlying air mass is a common property subject to ownership only when put to use by "diversion" through precipitation, whether by act of nature or by man.

It must be kept in mind that it is the moisture-laden air space which is the reservoir or "overhead basin"; the cloud is the inverted well shaft and pumping equipment; and nucleation, whether natural or artificial, is the energy which pumps water down to the earth. The foregoing analogy is not fanciful; it is fundamental to an understanding of the problems of proof of liability of weather modification hereafter discussed.

Although difficult for the layman to visualize, there is normally as much water in the clear air in front of a storm as there is in the clouds themselves. The cloud is the visual evidence of lifting, cooling, and condensing that water; it is the result, not the cause.

### III

#### THEORIES OF LEGAL LIABILITY FOR WEATHER MODIFICATION

Although, when the cases finally arise, it may be that liability will have to be predicated on negligence or intentional trespass, at this point there seems a considerable possibility that, in the early stages of the science, the cloud-seeder may be operating under rules of strict or absolute liability.<sup>20</sup> Even the imposition of absolute liability fails to put the plaintiff in such a case in an enviable position. The problems of proof which will face a plaintiff, assuming a doctrine of absolute liability, are discussed hereafter.

First, some consideration should be given to the factual environment for possible litigation. Legal liability will, in all probability, arise from

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<sup>18</sup> 84 F.2d 755 (9th Cir. 1936).

<sup>19</sup> *Id.* at 758.

<sup>20</sup> See rather detailed and excellent consideration of this point in Craig, *Legal Report on Liabilities Involved in Creation of Artificial Rainfall and Powers of the State to Regulate the Same*, CAL. WATER RESOURCES Bd., BULL. No. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA 226-38 (1955). Cases tried in other jurisdictions to date, however, have been presented and decided on negligence theories. See *Samples v. Irving P. Krick, Inc.*, Civil Nos. 6212, 6223, 6224, W.D. Okla. (1954), where a defense verdict followed normal negligence instructions; OPPENHEIMER, *LEGAL SITUATION* (Advisory Committee on Weather Control, Technical Report No. 6, 1957).

either (a) depletion of natural precipitation, or (b) from damage due to excessive precipitation.

### *A. Wrongful Depletion of Precipitation*

For purposes of discussion the two categories of weather modification, (1) "rainmaking," and (2) hail suppression, are treated separately. Most of the legal discussions published to date have dealt almost exclusively with rain-increasing activities. They have generally proceeded from a misconception of the physical operation and effect of storms and cloud-seeding techniques.

One of the earliest popular speculations regarding possible litigation relating to rainmaking activities was predicated on the sometimes wholly erroneous assumption that if a cloud were "milked," so to speak, a localized drouth for "downstream" lands would result.<sup>21</sup> This approach is based upon a stylized conception of a cloud as a floating tub of water with a comparatively fixed capacity, whereas it has been heretofore noted that physically a cloud is more nearly comparable to an inverted well.

To properly evaluate the legal theory behind any action arising out of a claim of wrongful depletion of precipitation it is necessary to consider the physical situations which may be involved.

Weather modification operations do not measurably alter the flow of moist or dry air over particular land. The techniques are utilized to condense and precipitate that moisture, but not to create it or to deprive other lands of it. Thus, a normal winter cold front moves across California in a generally northwesterly to southeasterly direction. The winds of the low pressure area which constitutes the storm's center travel in a counter-clockwise direction, carrying the warm, moist air, which is forced up over the cold front in a northeasterly direction. *This same moisture flows over a given parcel of land whether or not the front is artificially seeded.* With seeding, the intensity of the front may be increased sufficiently to cause precipitation at the point of convergence between the warm, moist air and the frontal movement.

The amount of water contained in the air as clouds or which drops to the earth as precipitation is but a small fraction of the total moisture present in the air mass. It is extremely doubtful that "diversions" of water from the air mass through intensification of particular storms have any material effect in dehydrating the air over the land. Thus, artificial nucleation may increase the capacity of the "pump," but it is doubtful that it thereby measurably depletes the air mass "basin." To the extent that it is feasible to seed a warm front, it is entirely possible that intensive artificial nucleation

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<sup>21</sup> Thus Gleaves, note 9 *supra*, refers to the rights of persons "over whose lands the clouds might otherwise drift." Los Angeles Daily Journal, March 29, 1948, p. 8, col. 4.



may narrow the band of precipitation, but again the total moisture available in the air mass is such that when artificial nucleation is stopped, the general range of precipitation from the front will tend to spread to its natural width again.

It is therefore suggested that, in the case of rain-increasing activities in frontal storms, there is serious factual objection to a theory of liability predicated on an assumed illegal diversion of water to the detriment of "downstream" lands. As heretofore noted, it is doubtful that rain-increasing activities can be effectively applied to air mass thunderstorms.

On the other hand, lightning suppression and hail prevention, through overseeding of storms, present a definite possibility of a claim of wrongful diversion of waters. This is perhaps less clear in frontal movements, where, notwithstanding the destruction of certain clouds in a storm front, the general frontal system should continue to afford near normal precipitation. On the other hand, in the case of air mass thunderstorms, once overseeded and destroyed they may not revive. When the freezing level of the storm has been turned to ice crystals, the inverted "well" is destroyed, and the capacity to "pump" water from the overhead "basin" is reduced accordingly.

If enough such thunderstorms were destroyed in a given watershed, it is entirely possible that a substantial reduction in rainfall and runoff could be calculated. The erratic nature and course of such storms would, however, probably present an almost insurmountable barrier of proof insofar as the individual landowner is concerned. The remedy would perhaps be available as a practical matter only to large water companies and water districts which could calculate reduction of rainfall over an entire watershed.

### *B. Floods and Hail Damage*

The most obvious area for weather modification litigation involves those instances where it is claimed that artificial nucleation caused flooding<sup>22</sup> or where ineffective attempts at overseeding are claimed to have resulted in increased hail damage.<sup>23</sup> Even if a doctrine of absolute liability is assumed, there remains the proof of causation and damage—a staggering burden nonetheless.

## IV

### PROBLEMS OF PROOF

Just as the rainmaker's greatest problem is furnishing his paying customers with satisfactory proof of results, so the lawyer's greatest problem is establishing causation and damages. By its nature, this proof will be made

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<sup>22</sup> *Samples v. Irving P. Krick, Inc.*, Civil Nos. 6212, 6223, 6224, W.D. Okla. (1954).

<sup>23</sup> *Auvil Orchards Co. v. Weather Modification, Inc.*, No. 40544, Super. Ct. Wash. (1956).

by experts, and it is not unusual for the same operator to find himself arguing on both sides of the point.<sup>24</sup>

Visual observation of cloud-seeding results, although attempted in the early stages of this work, is not generally satisfactory because of the extensive areas involved and the complexity of cloud and storm structures. In this, the rainmaker's law suit avoids some of the conflicts of the normal intersection accident; no one can credibly say that he "saw it happen."

On the other hand, much of the early "proof" of the results of rainmaking was derived from ground observations of actual torrential increases in precipitation at or about the time that either seeding was scheduled over a given area by airplane, or silver iodide was calculated to have intersected the storm. Since the airplane is seldom seen or heard in its high-altitude seeding operations and the course of silver iodide crystals is calculated on the basis of fragmentary winds-aloft reports, this type of evidence partook somewhat of old wives' tales.

In recent years a more scientific observer has entered the scene. As is well-known, a radar-scope will pick up intense precipitation. Radar of the right frequency could also detect the small droplets created by silver iodide crystals. As a result, some experimental work has been conducted in the field of "visual" seeding of storms. Theoretically, by this method a thin spot in a given storm could be seeded by an airplane directed by radar. And, presumably, the radar operator would furnish the lawyer with his first plausible "eye witness" to the effects of the operation.

If the problems of proof of causation are substantial, the calculation of damages invites pure speculation. By definition, cloud-seeding does not create rainfall where no clouds or potential precipitation exist. Since rain was falling or was likely to fall in any event, how much of the rainfall was to be attributed to the rainmaker? How much of the damage is to be attributed to the "rainmaker's water?"

One of the difficulties in evaluating the results of weather modification operations is that no two seasons or storms are exactly alike. No one can anticipate or say with assurance what the course or intensity of a particular storm will be.<sup>25</sup>

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<sup>24</sup> An amusing example was that of the California Electric Power Company. As one of the pioneer rainmakers, the company had seeded the clouds above its High Sierra watershed and had reported to its stockholders and the press that the snowpack had been increased as much as 14%. Unfortunately for the utility, however, it discovered in a rate proceeding before the California Public Utilities Commission, reported in 51 CAL. P.U.C. 189 (Dec. 46397, 1951), that protestants were using this new-found source of additional inexpensive hydroelectric power to reduce the company's claim of a needed rate increase. At that point in the hearing—and publicly since that date—the utility has been exceedingly conservative in its appraisal of the results of such a program, although it has continued to participate.

<sup>25</sup> Scientific and mathematical evaluation of the results of cloud-seeding is in its experimental infancy. This is a subject unto itself. See, e.g., CAL. WATER RESOURCES Bd., BULL. No. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA, c. III (1955). The most detailed and objective study to date is set forth in ADVISORY COMMITTEE ON WEATHER CONTROL, TECHNICAL REPORTS Nos. 1-5 (June 1957).

As heretofore indicated, the calculation of short-term damages for the individual land owner or small group of land owners is difficult to the point of being wholly impractical. Even in the field of long-range calculation of damage to a watershed area, the incomplete nature of existing rainfall records and knowledge of cyclical and basic climatic changes makes damage calculation tenuous.

Objectively viewed, therefore, the task of establishing liability for damages predicated upon weather modification operations is monumental. Viewed pragmatically, however, it may be observed that a combination of (1) a doctrine of strict liability, (2) proof of incautious claims on the part of the rainmaker,<sup>26</sup> and (3) the vast complexity of the subject matter, might be sufficient to result in some rather enormous judgments if the matter were taken to a jury of laymen. From such cases, the law respecting liability for weather modification operations may well be developed. Certainly, it is worthy of note that insurers are reluctant to enter this field.

## V

### WHO MODIFIES OUR WEATHER?

#### *A. Private Enterprise*

During the 1947-48 season, the first instances of rainmaking activity were reported. For the most part, the activity was carried on by individual ranchers or barnstorming pilots. The largest single program was that of the California Electric Power Company, in the Bishop Creek watershed. In at least one area, the work was the result of an informal local committee.<sup>27</sup> Another early project was by a mutual water company, using a contract operator from the Salt River Valley of Arizona.<sup>28</sup>

This same pattern of individual experiments continued through the 1948-49 and 1949-50 seasons; the dry ice operations of the California Electric Power Company was the only really substantial program other than the operations conducted by the United States Weather Bureau at Colfax Divide.

In the season 1950-51, operations were greatly broadened. Public agencies such as Kern County, the cities of Santa Barbara and San Diego, and the Montecito County Water District entered the field through contracts with commercial rainmakers. Informal associations and committees were replaced by non-profit corporations in other parts of the state. Through

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<sup>26</sup> Note 21 *supra* furnishes an example.

<sup>27</sup> Elsinore Rain Committee, February 2-28, 1948, in Elsinore Valley, involving five flights. CAL. WATER RESOURCES BD., BULL. NO. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA 18 (1955).

<sup>28</sup> Bear Valley Mutual Water Company, Redlands, March 13 to April 4, 1948, involving eighteen flights. *Ibid.*

these cooperative programs participation was obtained from counties, cities, public districts, and private water companies.

A 1951 state enactment<sup>29</sup> required the registration and licensing of persons engaged in weather modification. In the first year eight licenses were issued in the state. In 1956 eleven licensees were reported, including the Division of Forestry, of the State Department of Natural Resources.<sup>30</sup> Most of these licensees are commercial operators who contract with the public agencies and cooperative organizations financing the programs.

The problems of potential legal liability for rainmaking activity presented one of the major deterrents to the early development of this program. Some approached the projects with a determined belief in a necessity of experimental work in the field and a frank acceptance of the risks involved;<sup>31</sup> others insisted upon devious legal channels for their contributions;<sup>32</sup> still others refused to proceed without express sanction of the legislature.<sup>33</sup> Most of the commercial operations are comparatively thinly financed and the private corporations raising funds were so designed as to allow their total collapse without involving the financial responsibility of contributing individuals, companies, or public agencies. It would therefore seem pertinent to inquire whether the entire structure of private weather modification operations might not be badly shaken if any large judgments of liability were obtained. This leads to inquiry as to the advisability of public participation and control of such programs.

It should be noted, however, that the present agencies engaged in and supporting weather modification programs in California have the advantage of being composed of persons of fairly common interests and because of this avoid some of the pitfalls inherent in general political control of such a program.<sup>34</sup>

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<sup>29</sup> Cal. Stat. 1951, c. 1677.

<sup>30</sup> CAL. DEPT OF WATER RESOURCES, REPORT ON WEATHER MODIFICATION OPERATIONS IN CALIFORNIA, JULY 1952-JUNE 1956, table 1 (1957).

<sup>31</sup> Notable in this group was the thirsty City of San Diego, which had had the risks brought home to it so forcefully when "Mr. Hatfield's flood" burst the dam at Lower Otay Reservoir on January 27, 1916. See note 10 *supra* and corresponding text. Notwithstanding this experience, the City was in the forefront of the new rainmakers.

<sup>32</sup> The most normal being the purchasing of a report on experiments over which the contributor carefully exercised no control.

<sup>33</sup> See CAL. STAT. 1951, c. 1374, amending the powers of the Riverside County Flood Control and Water Conservation District to expressly authorize it to carry on a program of artificial nucleation.

<sup>34</sup> It might be asked, for instance, what solution would be reached by a centralized government seeding operation of the South Coastal Plain if, in a given dry cycle, a storm of some potential magnitude were to approach the area on December 31. Certainly from a water production standpoint, the residents of the semi-arid South could not afford to do less than their utmost to derive the full benefits from the storm. On the other hand, heavy precipitation immediately prior to and during a public festival such as the Rose Parade and Rose Bowl game could only cause substantial financial loss—to say nothing of the injury to the public pride of a good many voting citizens.

### *B. Public Participation*

As heretofore indicated, some public agencies, including cities, counties, and water districts, are to be found in the ranks of those who have pioneered the weather modification program in California. Although some early doubt existed, there seems now to be no real question as to the power of most public agencies interested in water conservation and flood control work to engage in such activity.<sup>35</sup>

Perhaps the greatest weakness to date in the existing pattern of programs is the fact that weather modification operations, to be effective, must necessarily cover entire watershed areas and the territorial scope of the operations is seldom coincident with existing political boundaries. Certainly this is one of the reasons that in some areas public agencies have found it necessary to participate in the programs through the agency of voluntary associations or non-profit corporations. Two bills were introduced in the 1955 session of the legislature to authorize the formation of Precipitation Control Districts,<sup>36</sup> but did not get out of committee. There appear to be no districts devoted solely and exclusively to this work in the state at the present time. The State of California, through the Division of Forestry, conducted some experimental work during the 1953-54 season in lightning dispersion for forest fire prevention. With this exception, the participation of the state in this program has been limited to study and analysis of work conducted by commercial organizations.

### *C. State Regulation*

Persons engaged in weather modification in California are presently required to obtain licenses from the Department of Water Resources.<sup>37</sup> This is essentially no more than a registration statute. The applicant is required to state its name and the qualifications of the meteorologist in charge, as well as to describe generally the operations and techniques to be used.<sup>38</sup> Reports of operations and evaluation statements are required to be filed<sup>39</sup> and notice must be published prior to conducting operations.<sup>40</sup>

The result of this licensing procedure has been to allow the state to accumulate considerable information on the nature of present operations,<sup>41</sup>

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<sup>35</sup> Craig, *Legal Report on Liabilities Involved in Creation of Artificial Rainfall and Powers of the State to Regulate the Same*, CAL. WATER RESOURCES Bd., BULL. NO. 16, WEATHER MODIFICATION OPERATIONS IN CALIFORNIA 238-39 (1955).

<sup>36</sup> ASSEMBLY BILL NOS. 1212, 2301, Calif. Legislature, 1955 Reg. Sess.

<sup>37</sup> Note 29 *supra* and corresponding text. This act, as amended, is now CAL. WATER CODE §§ 400-15.

<sup>38</sup> *Id.* § 404.

<sup>39</sup> *Id.* §§ 411-12.

<sup>40</sup> *Id.* §§ 407-10.

<sup>41</sup> CAL. DEP'T OF WATER RESOURCES, REPORT ON WEATHER MODIFICATION OPERATIONS IN CALIFORNIA, JULY 1952-JUNE 1956 (1957).

although no regulation or control of the operations themselves appears to have followed. It seems probable that as more definite analytical and statistical information becomes available, it will be necessary to assert some coordinating regulatory authority in order to prevent such things as an overlaying of weather modification operations in such a manner that the cloud-seeding activities of one operator interact upon those of another, resulting in overseeding and other undesirable effects.<sup>42</sup>

#### CONCLUSION

By way of summary, while it might be said that the science of weather modification has much ground yet to cover, it *is* a science. More than that, cloud-seeding may possibly be another substantial tool for water production in the hands of those who have come to live in the semi-arid Southwest.

When the first cases arise in the courts in connection with weather modification, the factual problems should far outweigh the legal uncertainty. The courts should, and undoubtedly will, develop new legal doctrines to deal with this new operating concept and practice.

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<sup>42</sup> The following is quoted from the ADVISORY COMMITTEE ON WEATHER CONTROL, FIRST INTERIM REPORT 8 (Feb. 1956): "With respect to the legal aspects of cloud seeding, the Committee believes that federal regulatory legislation is not at present indicated. In its view, the commercial seeding is, for the most part, in competent hands."