Weather Modification Law in the USA

Summary of court cases and principles of tort liability for cloud seeding, including both drought or flood allegedly caused by cloud seeding.

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Introduction

Weather modification is the effort of man to change naturally occurring weather, for the benefit of someone. The best-known kind of weather modification is *cloud seeding*, with the goal of producing rain or snow, suppressing hail (which can ruin crops), or weakening hurricanes.

People who live in the city do not give any thought to water: they turn on the faucet and water appears. But water is a constant concern for farmers and ranchers: drought can bankrupt a farmer and force a rancher to sell his/her cattle at an undesirable price. The legal right to access water is an important part of property law. There are many legal disputes about one person or one state extracting "too much" water from a river and thereby depriving everyone downstream. Because water is absolutely essential to the financial survival of farmers and ranchers, public hearings about allocations of water (including proposed cloud seeding) are often highly emotional events.

This essay briefly reviews governmental regulation of weather modification, then concentrates on judicial opinions regarding modified weather or cloud seeding and suggests how future weather modification torts might be argued. The scope of this essay does *not* cover liability for inadvertent weather modification, such as:

- release of heat or smoke from industrial smokestacks;
- injection of water vapor and particulates from jet airplane engines into the dry stratosphere;
- release of heat and airborne particulates from cities;
- pollution from automobiles;
- global warming from release of CO_2 by burning wood, coal, oil, or natural gas; or

- removal of ozone by release of fluorocarbons into the atmosphere.

This essay also does *not* consider purely local weather modification, such as dissipating fog in supercooled clouds at an airport.

This essay was initially written to inform:

- potential plaintiffs (e.g., farmers, ranchers, and people who might be victims of a flood),
- meteorology students, and
- attorneys and law students working in either environmental law or water law,

about the nationwide law in the USA that affects tort liability for cloud seeding. This essay is intended only to present general information about an interesting topic in law and is *not* legal advice for your specific problem. See my disclaimer at http://www.rbs2.com/disclaim.htm .

The history of cloud seeding also makes an interesting case study in the interaction between scientists and society: not only about the obligations and ethics of scientists, but also about how courts have avoided deciding cases involving technical issues about weather modification.

1. Technology

Release of silver iodide (AgI) into an existing supercooled cloud (i.e., air temperature between -39 and -5 celsius) can convert water vapor to ice crystals, which is called sublimation. The ice crystals nucleated by the AgI will grow and local water droplets will shrink. The latent heat released by converting water vapor (or liquid water) to ice will increase vertical air motion inside the cloud and aid the convective growth of the cloud. Raindrops or snowflakes will grow larger by falling through a taller cloud. Also, moist air from evaporated moisture in the soil will be sucked into the base of the cloud by convection (i.e., updraft), thus increasing the total amount of water in the cloud. Perhaps 30 minutes after the AgI release, snow may fall below the cloud. Depending on the temperature and humidity below the cloud, the snow may change to rain, or even evaporate, before reaching the ground.

To sharpen the focus of this essay on the law of cloud seeding, I have moved my discussion of cloud seeding technology to a separate document at http://www.rbs2.com/w2.htm . That document contains a discussion of:

- history of early (e.g., 1946-51) cloud seeding experiments, with emphasis on legal issues;
- some technical problems with cloud seeding experiments;
- a few excerpts from the official policy of the American Meteorological Society on cloud seeding technologies;
- environmental concerns and terse comments on the ethics of scientific experiments; and
- the need for more basic scientific research.

2. Governmental Licensing and Regulations

Various state governments license and regulate commercial weather modification.
These regulations are desirable because:

- weather is part of the natural environment that belongs to everyone.
- governments regulate the allocation of water from rivers to landowners, so it was natural for governments to also regulate attempts to enhance rainfall.
- some cloud seeders in the 1950s and 1960s were charlatans who exploited desperate farmers in a drought, which led to government programs to license cloud seeders, in order to protect the public.

There are two common features of state regulations:

1. ensure that commercial weather modification companies are competent (e.g., states often require cloud seeders to have earned at least a bachelor's degree in meteorology or a related field, plus have experience in weather modification); and
2. require companies have the resources to compensate those harmed by their weather modification (so-called "proof of financial responsibility"). In practice, such proof requires cloud seeders either to purchase liability insurance or to post a bond. Minimum amounts of insurance specified in old statutes are now woefully inadequate, because of inflation since the statute was written.[1]

The governmental regulation of cloud seeders is generally a two-step process. First, the government licenses individual cloud seeders. Second, the government grants a permit to a licensed cloud seeder to conduct operations at a specific place and range of times. Some states require public hearings before a cloud seeder is granted a permit.

One of the biggest problems with state regulation of weather modification is that the effects of weather modification commonly involve more than one state. For example, cloud seeding in the sky above Montana might later cause rain in North Dakota.

Most states in the USA have statutes about weather modification. Because there are so many statutes and because the statutes change with time, I have chosen not to summarize state statutes in this essay. Most states have posted their current statutes on the Internet, so they are easily available. Readers of statutes should contact an attorney who is licensed to practice in their state for an interpretation of technical legal terms in the statutes.

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[1] This is a common problem in many areas of law. Standler, *The Effect of Inflation on Monetary Values in Statutes and Contracts,* http://www.rbs2.com/gold.pdf 13 pp., 27 July 2004.

The Federal statute 15 USC § 330 (enacted 1971) requires reporting of weather modification to the Secretary of Commerce. Federal Regulations that implement this statute are found at 15 CFR § 908.

3. Court Cases

It is important to know that decisions of trial courts in the USA are *not* published (with the exception of some federal cases and a very few cases in some state courts), so it is difficult to find opinions of trial courts. Even if they were published, an opinion of a trial court is *not* precedent that is binding on future trials. Additionally, many appellate court cases in the USA are also *un*published and also can not be found conveniently. Therefore, there is no convenient way to find *all* of the cases in the USA involving a specific topic or legal issue. However, the following cases are what I found in May 1997 and September 2002 with a search of cases in all federal and all state courts in the comprehensive Westlaw online database, plus what I found by following footnotes in law review articles.

I list the cases in chronological order in this essay, so the reader can easily follow the historical development of a national phenomenon. If I were writing a legal brief, I would use the conventional citation order given in the *Bluebook.* I cite articles and books in the (Author, year, page) format; complete bibliographic data is given at page 34.

There are two basic ways that people in the USA can file litigation in court regarding weather modification:

1. Before the cloud seeding occurs, potential victims may apply to a court for an injunction prohibiting any future attempt at weather modification. Before an injunction can be issued, the plaintiff must be able to show an "irreparable harm" (i.e., destruction of something unique that can not be replaced) or "no adequate remedy at law" (i.e., money damages in either contract or tort litigation would not adequately compensate plaintiff).
2. After the allegedly modified weather causes damage to crops or buildings, the victims can sue the people who allegedly caused the modification in weather.

The first way is sometimes successful. However, I am not aware of any litigation in the USA that has held a cloud seeder liable for damage caused by a flood or other consequence of weather modification.

New York 1950

Slutsky v. City of New York, 97 N.Y.S.2d 238 (Sup.Ct. 1950).

New York City was conducting "experiments to induce rain artificially", in order to alleviate the "severe drought" that had diminished the City's water supply. The Plaintiff, Slutsky, sought an injunction to prohibit these experiments, because he feared the rain would interfere with his business, which was a country club and resort in Ulster County, north of New York City.

The trial court, in a terse opinion, denied the injunction and said:

> Apart from the legal defects in plaintiffs' suit (since they clearly have no vested property rights in the clouds or moisture therein), the factual situation fails to demonstrate any possible irreparable injury to plaintiffs.

97 N.Y.S.2d at 239.

The final paragraph of the opinion says:

> Contrasted with plaintiff's unfounded speculations as to possible damage, the affidavits of the experts for the City show that the experiments have reached a stage where it might reasonably be expected that rainfall may be both induced and controlled. This court must balance the conflicting interests between a remote possibility of inconvenience to plaintiffs' resort and its guests with the problem of maintaining and supplying the inhabitants of the City of New York and surrounding areas, with a population of about 10 million inhabitants, with an adequate supply of pure and wholesome water. The relief which plaintiffs ask is opposed to the general welfare and public good; and the dangers which plaintiffs apprehend are purely speculative. This court will not protect a possible private injury at the expense of a positive public advantage. Since plaintiffs have shown neither a factual nor legal basis for the drastic relief that they seek, the motion for a temporary injunction is denied.

97 N.Y.S.2d at 240.

The parenthetical remark about "no vested property rights" is a totally unsupported conclusion. Nowhere in this terse opinion is any discussion of property rights, vested or otherwise. This terse opinion cites no cases, no statutes, no books, and no scholarly articles in legal journals. Furthermore, the promise of experiments to increase rainfall, which the court accepts as reality, was, in fact, highly speculative in 1950. Indeed, the judge properly referred to the attempts at rainfall enhancement as an "experiment" five times in one page. Despite what the judge said, there was a possibility that the plaintiffs' business might suffer from heavy rainfall, and there is also a possibility that the experiments would be *in*effective in enhancing rainfall. Nonetheless, it was appropriate to balance the harms that might be suffered by one resort owner vs. ten million thirsty people in the City, and then rule in favor of the City. In my opinion, this judge reached the correct result, after mentioning the wrong reason (i.e., “no vested property rights”), no reasons (i.e., failing to cite any authority), and the right reason (i.e., the balancing of equities).

The opinion in this case was subsequently criticized by Judge MacPhail in Pennsylvania:

> The court's language concerning vested property rights in clouds and moisture was *dicta,* unsupported by legal authority or reason and was not favorably received. See 34 Marquette Law Review 262.

Pennsylvania Natural Weather Assn. v. Blue Ridge Weather Modification Assn., 44 Pa. D. & C. at 757, 1968 WL 6708 at *6 (Pa.Com.Pl. 1968).

After following the citation to the *Marquette Law Review,* one finds that Comment (which was written by three students while in law school) says only the following about the *Slutsky* case:

> ... the court offers no substantial reason for its parenthetical statement that a property owner has "no vested property rights in the clouds or the moisture therein." Indeed it is not at all clear just what the court means by its statement, for while it is true that a landowner has no vested property right in the moisture or clouds while over another man's land, it does not necessarily follow that he has no rights whatsoever to the natural benefits which will accrue to him from the normal rainfall. .... Thus the *Slutsky* case, while making a rather categorical statement regarding the rights of property owners in the clouds overhead, actually throws little light upon the problem involved.

Paul Binzak, Richard P. Buellesbach, Irving Zirbel, Comment: "Rights of Private Land Owners as Against Artificial Rain Makers," 34 Marquette Law Review 262, 264-65, Spring 1951.

Oklahoma 1954

Samples v. Irving P. Krick, Inc., Civil Nrs. 6212, 6223, 6224 (W.D.Okla. 22 Dec 1954).

This was apparently the first weather modification case in the USA to be presented to a jury. Plaintiff alleged that cloud seeding by Krick caused a flood on 18-19 November 1953 in Oklahoma City. The jury returned a verdict for the defendant. Despite the immense importance of this case both to the meteorology community and to the developing area of weather modification law, the federal judge did *not* prepare a written opinion for this case. This *un*reported case has been mentioned briefly in several law review articles.[2]

Incidentally, Krick was the chairman of the meteorology department at California Institute of Technology from 1933 to 1948. That university abolished the entire meteorology department and fired Krick in 1948, apparently because Krick was spending too much time on his private consulting business that forecasted the weather for paying clients, and not enough time on scholarly research in atmospheric physics.[3] Krick was one of the most famous commercial cloud seeders in the USA during the 1950s and 1960s. Among other flamboyant statements, Krick claimed he could predict weather more than one year in advance, with approximately

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[2] See, e.g., Grauer & Erickson (1956, p. 109), Oppenheimer (1958, p. 319), and Davis (1974, p. 413).

[3] See the essay by Judith Goodstein, a historian of science at California Institute of Technology, at http://oregonstate.edu/dept/Special_Collections/subpages/ahp/1995symposium/goodstei.html .

80% accuracy, using proprietary technology that he had developed. I have the impression that most meteorologists who were familiar with Krick's work believed that he was unprofessional and a fraud.

Washington state 1956

Auvil Orchard Company, Inc. v. Weather Modification, Inc., Nr. 19268 (Superior Court, Chelan County, Wash. 1956).

This is an *un*reported case that has been mentioned briefly in several law review articles.[4] Auvil was able to get a temporary injunction prohibiting cloud seeding for hail suppression. However, Auvil was unable to obtain a permanent injunction, because he was unable to prove that the cloud seeding had caused a flood.

Texas 1958-59

Southwest Weather Research, Inc. v. Duncan, 319 S.W.2d 940 (Tex.App. 1958), *aff'd sub nom. Southwest Weather Research v. Jones,* 327 S.W.2d 417 (Tex. 1959).

Southwest Weather Research was a commercial cloud seeding company that was attempting to suppress hail for the benefit of farmers in counties east of Jeff Davis County. A group of ranchers in Jeff Davis County noticed that the cloud seeding airplanes that were dispensing AgI above their land were causing local clouds to dissipate, thus allegedly decreasing rainfall on the ranchers' land. The ranchers applied for a permanent injunction against the cloud seeders. Before a hearing could be held on the permanent injunction, the judge granted a temporary injunction, in order to preserve the *status quo ante.* The issuance of this temporary injunction caused the reported appeal to the Texas Court of Civil Appeals and then to the Texas Supreme Court, both of which affirmed the issuance of the temporary injunction.

The judicial opinions note that the experts for the plaintiffs and defendant disagreed about whether cloud seeding could cause a decrease in rainfall, although there was agreement that "unimportant clouds with no rain potential could be dissipated." 319 S.W.2d at 942.

The Texas Court of Civil Appeals held:

> ... the landowner is entitled to such precipitation as Nature deigns to bestow. We believe that the landowner is entitled, therefore and thereby, to such rainfall as may come from clouds over his own property that Nature, in her caprice, may provide. It follows, therefore, that this enjoyment of[,] or entitlement to[,] the benefits of Nature should be protected by the courts if interfered with improperly and unlawfully. .... We do not mean to say or imply at this time[,] or under conditions present in this particular case[,] that the landowner has a right to prevent

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[4] See, e.g., Oppenheimer (1958, p. 319) and Davis (1974, p. 413).

> or control weather modification over land not his own. We do not pass upon that point here, and we do not intend any implication to that effect.

319 S.W.2d at 945. Duplicated in a companion case, *Southwest Weather Research v. Rounsaville,* 320 S.W.2d 211, 216 (Tex.App. 1958), *aff'd,* 327 S.W.2d 417 (Tex. 1959).

This case appears to be the only cloud seeding case in the USA in which the plaintiffs won. The later hearing is *un*reported, so it is not known whether the permanent injunction was granted. At the time of this case, there were neither state nor federal statutes or regulations on cloud seeding.

I note that several authors of law review articles appear to have missed the fact that *Southwest Weather Research* is a request for an injunction to prohibit future harm, *not* a tort case involving liability for past harm. Thus, *Southwest Weather Research* teaches us nothing about negligence and little about liability.

Nebraska 1960

Summerville v. North Platte Valley Weather Control District, 101 N.W.2d 748 (Neb. 1960).

A Nebraska state statute, enacted in 1957, allowed landowners to create a weather control district (which was a private corporation), and then vote on weather modification projects. Summerville, the plaintiff, lived outside of the district, but he owned property within the district. Summerville filed litigation challenging the constitutionality of the state statute, because he was affected by the decisions of the weather control district, but he had no opportunity to be heard. Both the trial court and the Nebraska Supreme Court found that the state statute was unconstitutional.

The opinion of the Nebraska Supreme Court is remarkable in that it says absolutely nothing about either weather modification or a landowner's rights to water from clouds. The Court decided the statute was unconstitutional because the statute had the same defects as an earlier statute that had been declared unconstitutional in the year 1924.

I am surprised that this case has apparently inspired no comment in law reviews. Similar cases could be brought in federal court under the Fifth Amendment to the U.S. Constitution by a resident of state X, challenging weather control activities in state Y that affects land in state X.

California 1964

Adams v. California, Nr. 10112 (Superior Court, Sutter County, Calif. 6 April 1964).

This is an *un*reported case that has been mentioned briefly in several law review articles.[5] There was a total of 170 plaintiffs who alleged that cloud seeding increased the flow of water in a river that caused a levee to break at midnight on 23 December 1955, which flooded their property. (Morris, 1968, pp. 165-167) In this flood in Yuba City, 37 people died and "467 homes were totally destroyed and 5745 homes damaged." (Mann, 1968, p. 691) These plaintiffs initially sued:

1. the cloud seeder, North American Weather Consultants;
2. the company that hired the cloud seeder, Pacific Gas and Electric Company (PG&E);
3. the state of California, who operated the levee that broke; and
4. fifty unknown defendants, who would be identified later.

Plaintiffs asserted two causes of action against the cloud seeder: (1) "negligent maintenance and operation" of the AgI generators and (2) cloud seeding was an ultrahazardous activity, which justified imposition of liability without needing to prove negligence. (Mann, 1968, p. 695)

Mann (1968, p. 692) notes in passing that, despite a statutory requirement for public notice of all cloud seeding, *none* of the plaintiffs were aware of the cloud seeding operation. The attorney for the plaintiffs "almost inadvertently learned of the cloud seeding" at a lunch conversation, about one year after the flood. (Mann, 1968, p. 694)

Plaintiffs originally sued in a California state court, the California attorney general removed the case to federal court, and the judge in the federal court remanded the case to state court. *Adams v. California,* 176 F.Supp. 456 (N.D.Cal. 1959).

There are two reasons why this trial did not resolve whether or not the cloud seeding had contributed to the flood:

1. Plaintiffs' attorney hired a meteorologist as an expert witness just a few months before the trial began (despite approximately five years of preparation by the attorney) and that expert wished to present a theory that had been mentioned in neither the pleadings nor discovery. (Mann, 1968, pp. 696, 701-02) Such late changes in the theory of the case is basically trial by ambush and the judge properly granted the defense motion to prevent such testimony. Because of poor preparation by the plaintiff's attorney, not all of the relevant facts and opinions were presented at trial.

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[5] See, e.g., Davis (1974, p. 413). The case is discussed in detail by Morris (1968) and Mann (1968).

2. During the trial, PG&E paid plaintiffs' attorney in return for his agreement not to appeal a possible verdict favoring either PG&E or the cloud seeder. After this agreement, plaintiffs' attorney concentrated on suing the state of California and apparently avoided cross-examination of witnesses presented by the defendants on cloud seeding issues. (Mann, 1968, p. 708)

The best reason why the cloud seeding did not contribute to the flood was that PG&E halted the AgI release three or four days before the levees broke. (Mann, 1968, pp. 690, 694) PG&E's attorney argued that any extra water from this cloud seeding passed by Yuba City one day before the levees broke. (Mann, 1968, p. 705) However, these reasons are not entirely convincing to me. We do not know if cloud seeding contributed to this flood, for the two reasons in the indented list in the previous paragraph.

After 26 days of hearings on pretrial motions and then an almost five-month trial, the court held:

> Plaintiffs may not recover against the PG&E or North American Weather Consultants as they have failed in their burden of proof. The court finds that neither the PG&E nor North American Weather Consultants produced any significant increase in rainfall or snowfall outside of the Lake Almanor water shed. The effects of cloud seeding were limited to the pre-determined target area which drains only into Lake Almanor. Lake Almanor never spilled at any time before or during the flood; and accordingly, any increase produced by cloud seeding was successfully impounded by that PG&E lake.
>
> The breaking of the levees was neither proximately caused nor contributed to either by the maintenance or by the operation of the artificial rain making equipment of any defendant in this lawsuit.

Judge John P. MacMurray, *Adams v. California,* Nr. 10112 (Superior Court, Sutter County, Calif. 6 April 1964), quoted in both (Morris, 1968, pp. 182-83) and (Mann, 1968, p. 708).

Despite losing against both PG&E and the cloud seeder, plaintiffs won against the state of California, because of negligent design, construction, or maintenance of the levees. (Mann, 1968, p. 709) Rather than have a trial on damages, the State of California agreed to pay plaintiffs a total of US$ 6,300,000, which was less than half of what plaintiffs had initially requested. (Mann, 1968, p. 709) Incidentally, the California Supreme Court had ended sovereign immunity in California a few years before the *Adams* trial began. If sovereign immunity had existed, then plaintiffs could not have won against California.

The attorney for PG&E estimated that *if* cloud seeding had increased the rainfall by 15%, then the cloud seeding contributed an extra "572 acre feet" (i.e., 7×10^5 m^3) of water upstream from the levee, which the attorney argued was a "minuscule amount" and "could not have contributed in any significant degree to the breaking of the levees." (Morris, 1968, pp. 180-81; Mann, 1968 p. 705).

no jury in this case

Attorneys involved in the case initially estimated that trial of this case would require between 12 and 18 months of court time, mostly because of the evidence of damage by 170 plaintiffs. (Morris, 1968, p. 170-71) Because of the anticipated extraordinary length of this trial, it was difficult to find a judge who would hear this case. The case was tried in Sutter County, which had only 12,000 registered voters who could be asked to serve on a jury. After inquiries about possible bias and availability for a year-long trial, the jury pool was reduced to 120 people. (Morris, 1968, pp. 172-73; Mann, 1968, p. 699) The attorney for PG&E candidly wrote:

> Of the 400 potential jurors, only 120 agreed that they would serve for one year. All but 10 of them were women, and those 110 women had generally a background as a grocery store clerk, or a packinghouse worker. Both sides, after spending literally years in preparing technical testimony, were somewhat discouraged with the idea of having to present this information to a level of women in their 60s who had an inadequate scientific knowledge to properly follow the testimony.

Morris, 1968, p. 173.

As an aside, I note that most litigators in the USA express their *belief* in the wisdom of juries, without any evidence to support that belief, and in the face of the obvious inability of jurors who have no education in science and mathematics to understand scientific evidence. Even worse, jurors are called upon to evaluate conflicting expert opinions, which is much more difficult than understanding the basis for each opinion. If doctoral-level scientists can not agree on conclusions, what hope is there for people on the jury (some of whom are probably high-school dropouts and none of whom have taken even introductory college classes in calculus and physics) to analyze and evaluate such expert testimony? While I understand and agree with the above-quoted statement of Attorney Morris, I also reject his dim opinion of stupid old women. The *men* in Sutter County, California would be equally unable to understand and to evaluate scientific evidence. The problem is that most jurors are ignorant of science and mathematics, *not* that jurors are women.

Furthermore, the plaintiffs were reluctant to pay approximately US$ 36,000 in jurors' fees (i.e., a modest US$ 10/day, for a ten-month trial of 20 days/month, for a total of 18 jurors [12 jurors and 6 alternate jurors]).

For these reasons, attorneys for both plaintiff and defendant agreed to try the case without a jury. (Morris, 1968, p. 173)

Pennsylvania 1968

Pennsylvania Natural Weather Association v. Blue Ridge Weather Modification Association, 44 Pa. D. & C.2d 749, 1968 WL 6708 (Pa.Com.Pl. 1968).

The plaintiff, Pennsylvania Natural Weather Association, was a group of property owners in Fulton County, Pennsylvania. The defendant, Blue Ridge Weather Modification Association, was a commercial cloud seeding company that had attempted in 1963 and 1964 to suppress hail in the states of Maryland, West Virginia, and Virginia, in addition to Franklin County, Pennsylvania. Franklin County is adjacent to Fulton County, where the plaintiffs lived.

There had been a "severe drought" in 1963, 1964, and 1965 in the northeastern USA, including Fulton County. Plaintiffs sought an injunction preventing defendants from seeding clouds. The legal issue before the court was

> ... the question of whether or not a landowner outside of the "target area" is entitled to weather in its natural form, even though defendants' activities were not intended to, and perhaps did not, in fact, affect the amount of rainfall Fulton County received or did not receive. To state it another way, does a landowner have a right to weather unmodified anywhere?

44 Pa. D. & C. at 752, 1968 WL 6708 at *2.

The court denied plaintiff's request for an injunction, because of two reasons:

1. Plaintiffs had not proven that they were harmed by the cloud seeding. For example, there was a drought in 1965, but defendant could *not* possibly have caused the drought in 1965, because defendant did no cloud seeding in that year. The drought in 1963 began before the defendants began their cloud seeding program. Plaintiffs had not proven that there was a "threat of immediate and irreparable harm", which is one of the conditions for granting an injunction. 44 Pa. D. & C. at 763-64, 1968 WL 6708 at *9.

2. There was an adequate remedy at law, which barred the court from granting the equitable remedy of an injunction. After the plaintiff filed this litigation, the Pennsylvania legislature in 1965 enacted a statute regulating cloud seeding. That statute specifically forbade weather modification activities in any county "where the county commissioners enact a resolution stating that such actions are detrimental to the welfare of the country." In 1967, the Pennsylvania legislature repealed that statute and enacted a new statute that "specifically provides for damage compensation to property owners" who are harmed by weather modification activities in Pennsylvania. These statutes made this case moot. 44 Pa. D. & C. at 762-64, 1968 WL 6708 at *9-*10.

Because this case was decided on grounds of "no irreparable harm" and "adequate remedy at law", the court's opinions about the law of cloud seeding should be regarded as *obiter dicta.* Moreover, this opinion was issued by a trial court, which has no precedential value, not even in

Pennsylvania. Nonetheless, the court's opinions are quoted here, because such opinions are sparse, so any judicial opinion (even an incidental remark) is significant:

> It seems to us that one of the elements of land in its "natural condition" must be weather in its natural form, including all forms of natural precipitation. .... [A landowner] does not assume the risk of weather modification activities by neighbors.

44 Pa. D. & C. at 756, 1968 WL 6708 at *5.

> We are of the opinion that clouds and the moisture in the clouds, like air and sunshine, are part of space and are common property belonging to everyone who will benefit from what occurs naturally in those clouds. There could be just as much injury or harm from weather modification activities as there could be from air and water pollution activities. We hold specifically that every landowner has a property right in the clouds and the water in them. No individual has the right to determine for himself what his needs are and produce those needs by artificial means to the prejudice and detriment of his neighbors. However, we feel that this cannot be an unqualified right. .... cloud seeding has been used[,] and will continue to be used[,] to produce rain to relieve the water shortage in our urban areas. We feel then that weather modification activities undertaken in the public interest, as opposed to private interests, and under the direction and control of governmental authority should and must be permitted.

44 Pa. D. & C. at 759-60, 1968 WL 6708 at *7.

The Judge made the following conclusions of law:

1. Moisture in the clouds is common property belonging to everyone who will benefit from what occurs naturally in the clouds.
2. Every owner of land has a property right in the moisture in the clouds and the right to receive that moisture in its natural form subject to such weather modification activities as shall be carried out by governmental authorities in the public, as opposed to private, interest.
3. The activities of defendants are lawful and do not constitute a nuisance.
4. There is no threat of immediate and irreparable harm to plaintiff as a result of defendants' activities.
5. The burden is on plaintiff to show damage or that damage will result as a certainty from defendants' activities.
6. Plaintiff now has an adequate remedy at law and the issue raised by this case is moot in Pennsylvania.

44 Pa. D. & C. at 763-764, 1968 WL 6708 at *9-*10.

There is no further opinion in the Westlaw database for this case.

Montana 1974

Montana Wilderness Association v. Hodel, 380 F.Supp. 879 (D.Mont. 1974).

Bonneville Power Administration (BPA), an agency of the federal government, proposed to do cloud seeding in a wilderness area, to increase the volume of water in a river that was used for hydroelectric power. There is a federal statute that protects the "natural condition" of wilderness areas from interference by man. Plaintiffs were concerned that the proposed cloud seeding would harm or alter the wilderness area. Plaintiffs filed litigation in federal court, asking the court for declaratory judgment and an injunction prohibiting planned cloud seeding. However, five days after plaintiffs filed this lawsuit, the BPA "cancelled a contract which had been granted to North American Weather Consultants" for cloud seeding. 380 F.Supp. at 880. In a terse opinion, the judge refused to hear the case, because the case was moot: the BPA had already decided not to seed clouds. Because there were no further cloud seeding proposals in the next several years, Davis (1977, p. 48, n. 142) commented: “It would appear that the plaintiffs won their point without the need to go to trial.”

South Dakota 1977

Lunsford v. U.S., 418 F.Supp. 1045 (D.S.Dak. 1976), *aff'd,* 570 F.2d 221 (8thCir. 1977).

There was a flood in Rapid City, South Dakota on 9 June 1972 that killed 283 people and caused extensive property damage. Plaintiffs alleged that the flood was caused by an experimental cloud seeding program operated by the South Dakota School of Mines and Technology, under contract to the U.S. Government.

The court opinion considers only some preliminary, technical issues in law that do *not* involve the merits of this case:

1. Whether the plaintiffs can maintain a class action, on behalf of all of the victims of this flood.
2. Whether the plaintiffs need to exhaust their administrative claims before filing litigation.
3. Whether the U.S. Government was immune under 33 U.S.C. § 702c, which provides for immunity for floods. That statute was enacted in the context of flood control (e.g., dams, dikes, and levees) legislation in the year 1928 and it is not clear if the statute also applied to floods caused by cloud seeding.

The trial court's opinion mentions neither "cloud seeding" nor "weather modification", but there is a terse mention in the appellate court's recitation of the facts of the case.

There is no further opinion in the Westlaw database for this case.

North Dakota 1981

Saba v. Counties of Barnes ... and Weather Modification, Inc., 307 N.W.2d 590 (N.D. 1981).

Plaintiffs alleged that negligent cloud seeding by a private company, Weather Modification, Inc., caused heavy rain in Bismark, North Dakota on 31 July 1975 that damaged plaintiffs' property.

Plaintiffs originally sued the city of Bismark, alleging "failure to properly maintain its sewer system." The city answered the original complaint by asserting that "the torrential rain was an act of God." Plaintiffs then amended their Complaint to delete the defendant city of Bismark, to add as new defendants the cloud seeding company and nine counties that had hired the cloud-seeding company, and to proceed on a new theory of negligent cloud seeding. Although there were only two plaintiffs with known claims for damages, plaintiffs' amended Complaint attempted to proceed as a class action, on behalf of all potential plaintiffs. *Id.* at 596.

The trial court refused to certify the class action and the South Dakota Supreme Court affirmed. The opinion of the South Dakota Supreme Court is limited to the possibility of a class action and does not reach the merits of the negligent cloud seeding claim, which had not yet been heard by the trial court. The Supreme Court of North Dakota coldly rejected plaintiffs' attorney request for certification of the class action:

> We agree with the plaintiffs that one of the reasons for class-action status is to permit a sharing of the expenses of litigation. [citation omitted] However, we cannot determine that the class-action rule was intended to permit the plaintiffs to obtain class-action status in order to permit them to solicit additional plaintiffs who might be willing to share the costs of exploring a novel theory of liability. **....** In this instance Plaintiff Mourhess alleged damage in the amount of $11,250 and Plaintiff Saba alleged damage in the amount of $35,140. Plaintiffs' attorney has estimated the cost of litigation at $10,000. We cannot determine, as did the United States Supreme Court in *Eisen,* [417 U.S. 156] that the damages are so inconsequential that economic reality dictates that the petitioner's suit proceed as a class action or not at all. Plaintiffs argue that they do not have the financial resources to sustain such a suit in their individual capacities, and that may well be the situation. However, we do not believe the class-action rule was intended primarily as a vehicle by which parties whose alleged damage exceeds the estimated costs of litigation but who do not have the financial resources to sustain the costs of litigation are enabled to finance their claims, although one of the benefits to parties of class-action status is a sharing of the litigation expenses.

Saba, at 596.

There is no further opinion in the Westlaw database for this case.

California 1987-1990

First English Evangelical Lutheran Church of Glendale v. County of Los Angeles, 482 U.S. 304 (1987), *on remand,* 258 Cal.Rptr. 893 (Calif.App. 1989), *cert. denied,* 493 U.S. 1056 (1990).

The Church owned five buildings situated on 21 acres of land in a canyon in Palmdale, California. On 9-10 February 1978, there was a total of 28 cm of rain, and the ensuing flood in the canyon destroyed the buildings. Following that flood, the County of Los Angeles enacted a temporary ordinance that prohibited construction of any buildings in the canyon. Because the Church could not rebuild in the canyon for $2\frac{1}{2}$ years, that ordinance effectively diminished the value of the Church's land. The Church then sued the County, alleging two causes of action:

1. an inverse condemnation action, seeking compensation for the County's taking of the land, contrary to article I, § 9 of the California Constitution. (Similar rights are also contained in the Fifth Amendment to the U.S. Constitution.)

2. tort liability for cloud seeding conducted by the County's Flood Control District.

The trial court granted the County's motion "for judgment on the pleadings on the second cause of action in tort and inverse condemnation based on cloud seeding". 258 Cal.Rptr. at 895. That terse remark is the only information in the published opinions of the California courts on this important matter! A trial was held on damages for the County's alleged taking of the land, and "at the close of plaintiff's evidence on liability, the court granted defendants' motion for nonsuit." *Id.* at 896.

The California Court of Appeal affirmed in an unpublished opinion, and the California Supreme Court refused to review the case. The Church then appealed to the U.S. Supreme Court, which agreed to hear the case and then rendered an opinion. The case then returned to the California Court of Appeal, which held that the County's temporary ordinance "substantially advances the highest possible public interest — the prevention of death and injury", so the Church's "complaint does not state a valid claim for a compensable taking." *Id.* at 905. The case was then remanded to the trial court for "further proceedings ... as to the cause of action for inverse condemnation based on cloud seeding." *Id.* at 907. There is no further opinion in the Westlaw database for this case.

Incidentally, there has been a suggestion[6] that the California Court of Appeals, 258 Cal.Rptr. 893, misunderstood the U.S. Supreme Court's opinion in the same case.

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[6] *McDougal v. County of Imperial,* 942 F.2d 668, 676 (9thCir. 1991).

conclusions about case law in the USA

Despite the potential immense economic importance of cloud seeding, and the important legal issues about who has property rights in clouds that might provide rain:

- *None* of these reported judicial opinions discuss negligent cloud seeding.
- *Few* of these reported opinions discuss property rights of landowners to rain from the clouds that are either above their land or upwind from their land.
- Since 1980, there have been *only two* reported cases on the topic of either: (a) injunctions prohibiting cloud seeding or (b) liability for alleged negligent cloud seeding. The judicial opinions in each of these two cases failed to discuss the merits of the cloud seeding issue.
- Apparently no plaintiff has alleged a wrongful deprivation of precipitation in a tort case involving cloud seeding in the USA.

During the past fifty years, the courts in the USA have not resolved any of these important issues. A law professor said[7] that the above cases are "sparse and contradictory". *Slutsky* in New York absolutely rejected a landowner's rights in water from clouds; *Southwest Weather Research* in Texas accepted a landowner's rights in water from clouds and found that the landowner might be harmed by future cloud seeding; while *Pennsylvania Natural Weather Assoc.* accepted a landowner's rights in water from the cloud with some conditions, but found that the plaintiffs had not proved they would be harmed by future cloud seeding.

There are a number of reasons why judges have neither decided nor explained the law in this new area:

- Litigation is expensive and slow. Plaintiffs often exhaust their financial resources before all of the possible appeals can be heard, which forces a premature end to an interesting case.

- In other cases, subsequent events (e.g., end of a drought) may make it unimportant to plaintiffs to resolve all of the issues in their original complaint.

- Sometimes defendants offer a substantial financial settlement to plaintiffs, in order to avoid the possibility of a reported judicial opinion that could serve as unfavorable precedent for the defendants in future cases. Plaintiffs accept the offer and the case ends, without any judicial opinion on the merits. (I do not know that this has happened in any weather modification case, but it is common in some other areas of law.)

- The job of judges is *only* to decide the facts or law necessary to dispose of the particular case before them, *not* to write an essay about novel legal issues that are *un*necessary to the disposition of the current case. When a judge does write about unnecessary issues, the judge's comments are *obiter dicta,* which are *not* precedent for future cases.

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[7] Davis (1974 , p. 433).

In particular, it is rare for a judge in an appellate court to give guidance to the judge in the trial court on matters not specifically mentioned in the appeal. For example, as mentioned in several cases above, an interlocutory appeal on certifying a class action *only* decided the desirability of the class action, without any discussion of the merits of the case, even if the appellate judge should know that the trial judge will need guidance in dealing with novel, *un*precedented legal issues in a future trial on the merits. In other words, appellate judges exist to correct mistakes already made by lower court, *not* to help avoid mistakes that might be made by the lower court in a future trial in the case.

This limited role of judges is contrasted with the job of the scientist who writes a paper or book for publication (or with a law professor who writes an article in a law review), where the author discusses a subject thoroughly.

- Most judges are burdened by a very large number of cases, so they do not have adequate time to write a careful, scholarly discussion of novel issues that would be worthy of publication.

- When a judge makes a decision on any important new topic, it is almost certain that a substantial number of people (including the losing party in litigation and his/her supporters) will react with anger and scorn, simply because they disagree with the judge's decision. The angry public reaction discourages judges from saying more than the minimum amount necessary to dispose of a case.

- And, finally, because most attorneys and judges went through high school and college taking the minimum number of classes (and the easiest classes) in science and mathematics, they are now poorly prepared to handle cases involving scientific evidence (e.g., about cloud seeding). There is a natural tendency for judges, like everyone else, to avoid what they do not understand. In one of the earliest reported cases involving cloud seeding, the Texas Supreme Court twice mentioned “complicated scientific problems”. 327 S.W.2d at 421. To me, as a scientist, such problems are no more complicated than in many other areas of scientific or engineering research.

I remarked above on the angry public reaction to a judge's decision. Let me compare and contrast the situation in science to that in law. Research scientists become famous for writing landmark papers in scholarly journals, and many scientists would eagerly seize the opportunity to write a publication on an important new topic. It is rare for a scientific publication to cause an angry reaction among many readers. Indeed, most scientific accomplishments are ignored by journalists, politicians, and the public. In contrast, meteorologists who are involved in public hearings on cloud seedings are often exposed to an angry, political situation that is unlike anything in conventional scientific research. And, *un*like the situation in science, opinions expressed at hearings on cloud seeding may be based on superstition, emotions (e.g., fear or anger), politics

(e.g., having their personal concerns ignored or rejected by a bureaucrat whom they neither trust nor respect), religion (e.g., it is immoral to modify God's weather), ...

Farmers and ranchers opposed to cloud seeding have used violence and sabotage against both cloud seeders and those sponsoring cloud seeders.[8]

4. General Principles of Tort Liability

As discussed above, judges have neither decided nor explained tort liability for negligent or wrongful cloud seeding. However, the general principles of tort liability are well established in many other areas (e.g., negligence, medical malpractice, etc.) and these general principles would probably be used by judges to decide cases involving negligent or wrongful weather modification.

There are several broad kinds of torts:

- **strict-liability torts** Plaintiff only needs to prove that defendant caused plaintiff's injury, without also needing to prove wrongful or negligent conduct by plaintiff. When plaintiff wins a strict-liability tort case, the court orders defendant to compensate plaintiff, as a way of redistributing wealth (i.e., a large corporation or insurance company pays an injured individual, as part of the cost of doing business), *not* as compensation for a wrong. There are only a few kinds of strict-liability torts, of which "abnormally dangerous activities" *might* be relevant to cloud seeding.

- **fault-based torts** in which the injury to plaintiff was produced as a result of some kind of negligent or wrongful act by the defendant. Essential elements in proving these torts is showing that defendant owed a specific duty of care to the plaintiff and that defendant breached his/her duty.

- **trespass or nuisance**, which require either intent, negligence, or abnormally dangerous activity.

The plaintiff in a fault-based tort case needs to prove *each* of the following four elements of a tort:

1. **duty**, a standard of conduct, e.g., specify the appropriate care that defendant should have used.
2. **breach of that duty**, e.g., the defendant's conduct was negligent.
3. **injury**, proof of the harm that the plaintiff suffered as a result of defendant's act(s), or defendant's failure to act. *If* weather modification causes an amount of rain that is only slightly different from the average rainfall, I suggest at pages 29 and 32, below, that there is no injury to plaintiff.
4. **causation**, proof that defendant caused the injury. It is important to understand that, even if a cloud seeder was negligent, there is *no tort liability* unless the cloud seeder can be proved to have caused the harm to a plaintiff. In the context of weather modification torts, the proof of

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[8] Howell, 1965, p. 329; Carter, 1973, p. 1349.

causation has been so difficult that I discuss this topic in a separate section, beginning at page 25, below.

If the court accepts a strict-liability tort, the plaintiff can skip the proof of the first two elements of fault-based torts, above: duty and breach of that duty. Superficially, strict-liability torts appear to be easier for a plaintiff to argue than fault-based torts. However, unless strict-liability for weather modification is established in a statute, the plaintiff will need to convince the judge that strict liability applies, which may be more difficult than proving either negligence or nuisance in a fault-based tort.

Possible strict-liability torts

"Abnormally dangerous activities" are defined in Restatement Second of Torts, § 520 (1977). Legislatures in three states have enacted statutes that specify cloud seeding is *not* an abnormally dangerous activity (or the older term "ultrahazardous activity"[9]), thus strict liability can not apply to cloud seeders in those states:

- North Dakota § 61-04.1-37(1) (enacted 1981);
- Texas Agricultural Code, Title 9, § 301.302(a) (enacted 2003)[10];
- Wisconsin § 93.35(14)(a) (enacted 1981).

On the other hand, a Pennsylvania statute appears to establish strict liability for any drought or "heavy downpours" that the state weather modification board finds to have been caused by weather modification. 16 Pennsylvania Statutes § 1114 (enacted 1968).

In other states, it is an *un*resolved question whether judges will accept strict-liability torts against cloud seeders.

Possible fault-based torts

Plaintiffs have several possible fault-based tort actions against cloud seeders.

Negligence per se Two states have statutes that explicitly say failure of a cloud seeder to follow the licensing requirements or state regulations is *negligence per se:*

- Colorado § 36-20-123(2)(a) (enacted 1972);
- Wisconsin § 93.35(14)(d) (enacted 1981).

In these states, if the plaintiff can prove that the cloud seeder violated state law or regulations, then, as a matter of law, negligence is automatically proved.

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[9] "Ultrahazardous activity" was the nomenclature in the First Restatement of Torts for what the Second Restatement in 1977 called an "abnormally dangerous activity".

[10] This Texas statute was first enacted in 1966. (Davis, 1974, p. 430).

In the absence of such a statute, there is a common law duty to obey statutes and regulations that are designed to prevent harm. Restatement (Second) of Torts, §§ 285(a), 286, 288B(1) (1965).

Negligence The cloud seeder is held to a standard of care of a competent, professional meteorologist who was engaging in cloud seeding, and who takes reasonable care to avoid foreseeable and unreasonable risks.[11] The standard of care can be established in several ways:

- a statute or government regulation that is intended to protect the public safety. Restatement Second of Torts § 286 (1965).
- a standard or code of conduct adopted by a professional society.
- testimony of another meteorologist who has experience in weather modification.

However, conduct that conforms with all relevant statutes, regulations, standards, and customs in the trade might still be negligent, if the conduct presents an unreasonable risk of harm.

A commercial cloud seeder who advertises his/her services as unusually competent (e.g., having tens of years of experience, employing scientists who have earned a Ph.D. in meteorology, etc.) can properly be held to a higher standard than a typical cloud seeder.[12] This is an area familiar to attorneys who concentrate in tort litigation: advertising can come back to haunt a defendant.

As an example of how a negligence claim might arise, Jones (1991, p. 1177) gave an example of a cloud seeder who decides to seed on a day for which heavy rains are forecast, therefore enhancing heavy rain to a catastrophic condition. I agree that it is a good example of negligence, but the example contains two hidden assumptions: (1) that forecasts of the amount of rain are usually accurate, and (2) that cloud seeding usually enhances (*not* decreases) the amount of rain. In an actual case, plaintiffs would need to prove those assumptions were true, which could be a formidable burden.

Trespass is the invasion of either a person or a thing upon the land owned by another person. Restatement Second Torts §§ 158, 165 (1965).

Typical cloud seeding releases tens or hundreds of grams of nontoxic AgI into a cloud or the air. Some legal commentators[13] have suggested that this release of AgI *might* be considered a trespass on the plaintiff's land. On the other hand, several state statutes declare that weather modification is *not* a trespass:

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[11] Note that the standard is *not* an average meteorologist, because that would automatically make half of the cloud seeders negligent!

[12] Restatement (Second) of Torts § 289(b) and § 299A (1965).

[13] See, e.g., Davis, 1974, p. 430; Ferdon, 1984, pp. 688-89; Jones, 1991, pp. 1174-75.

- Colorado § 36-20-123(1) (enacted 1972) ("The mere dissemination of materials and substances into the atmosphere pursuant to an authorized project shall not give rise to the contention or concept that such use of the atmosphere constitutes trespass or involves an actionable or enjoinable public or private nuisance.");
- North Dakota § 61-04.1-37(2) (enacted 1981) ("Dissemination of materials and substances into the atmosphere by a permittee acting within the conditions and limits of the permittee's permit shall not constitute trespass.");
- Utah § 73-15-7 (enacted 1973) ("The mere dissemination of materials and substances into the atmosphere or causing precipitation pursuant to an authorized cloud-seeding project shall not give rise to any presumption that such use of the atmosphere or lands constitutes trespass or involves an actionable or enjoinable public or private nuisance.");
- Wisconsin § 93.35(14)(b) (enacted 1981) ("Dissemination of materials and substances into the atmosphere by a permittee acting within the conditions and limits of his or her permit shall not give rise to the contention that the use of the atmosphere constitutes trespass.").

I believe that a trespass claim for the AgI itself is specious, because:

- the quantity of AgI is trivial.
- the AgI occurs as microscopic crystals, which are real, but not perceptible to the human senses.
- the AgI itself is essentially harmless (Standler and Vonnegut, 1972), unlike a noxious pollutant.
- most of the AgI is contained in either the air, cloud, or rainwater, none of which may touch the land of a plaintiff who alleges that cloud seeding deprived him/her of rain.

Instead of focusing on the AgI itself, I suggest focusing on the *effect* of the AgI in either:

(a) diminishing rainfall that would have otherwise occurred or

(b) causing excessive rainfall (e.g., a flood).

In fact, the first law review article written on the subject of weather modification said:

> If the cloud seeder intentionally causes rain to fall on the plaintiff's land, a trespass is committed as clearly as if he had turned a stream of water from a hose on plaintiff's house. Where the defendant does not intend to cause rainfall on the plaintiff's land, the plaintiff would be required to show that the defendant was either negligent or engaged in an ultrahazardous activity.

anonymous, 1949, p. 532.

It is well-established law that surface water entering plaintiff's land can be a trespass. For example, consider the following cases:

- *Red Lake Hunting & Fishing Club v. Burleson,* 219 S.W.2d 115 (Tex.Civ.App. 1949);
- *Levene v. City of Salem,* 229 P.2d 255 (Or. 1951);
- *Yenchko v. Grontkowski,* 122 A.2d 705 (Penn. 1956);
- *Corrington v. Kalicak,* 319 S.W.2d 888 (Mo.Ct.App. 1959);
- *Herro v. Board of County Road Commissioners,* 118 N.W.2d 271 (Mich. 1962);
- *Bell v. Union Electric Co.,* 367 S.W.2d 812 (Mo.Ct.App. 1963);
- *Union Pacific Railroad v. Vale, Oregon Irrigation Dist.,* 253 F.Supp. 251 (D.Or. 1966);
- *First Kingston Corp. v. Thompson,* 152 S.E.2d 837 (Ga. 1967);
- *Senn v. Bunick,* 594 P.2d 837 (Or.App. 1979);

• *Ratliff Co. v Henley,* 405 So.2d 141 (Ala. 1981);
• *Mack v. Edens,* 412 S.E.2d 431 (S.Car.App. 1991);
• *U.S. v. Imperial Irrigation Dist.,* 799 F.Supp. 1052 (S.D.Calif. 1992);
• *Easterling v. Awtrey Building Corp.,* 770 So.2d 606 (Ala. 1999);
• *Canton v. Graniteville Fire Dist. Nr. 4,* 762 A.2d 808 (Vt. 2000);
• *Dougan v. Rossville Drainage Dist.,* 15 P.3d 338 (Kan. 2000);
• *Sumitomo Corp. v. Deal,* 569 S.E.2d 608 (Ga.App. 2002).

Liability for trespass requires plaintiff to prove either: intent, negligence, or "abnormally dangerous activity" by the defendant.[14] It is an *un*answered question whether a cloud seeder's intent to cause rain would justify trespass liability for a consequential flood.

Private nuisance "A private nuisance is a nontrespassory invasion of another's interest in the private use and enjoyment of land."[15] A private nuisance requires[16] an invasion that is either:
1. "intentional and unreasonable" or
2. unintentional and either:
   a. negligent conduct,
   b. reckless conduct, or
   c. abnormally dangerous activities.

Several law review notes[17] have discussed how nuisance might be applied to cloud seeding.

Two states, Colorado and Utah, have statutes that declare that weather modification is *neither* a public *nor* a private nuisance:
• Colorado § 36-20-123(1);
• Utah § 73-15-7 (no presumption of nuisance).

The famous torts textbook by Prosser and Keeton gives three possibilities for enjoining nuisances:
(1) if defendant's activity is "reasonable" *and* if that activity causes an "insubstantial" inference with the use of plaintiff's land, then neither an injunctive nor a tort remedy is available.
(2) if "defendant's activity is socially desirable" and "reasonable", then the injunction is not granted, but plaintiff can sue in tort for damage that plaintiff suffers if the effect of the defendant's acts is "substantial ... such as would be offensive or inconvenient to the normal person".

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[14] Restatement Second of Torts, § 166 (1965).

[15] Restatement Second of Torts, § 821D (1979).

[16] Restatement Second of Torts, § 822 (1979).

[17] See, e.g., anonymous, 1960, pp. 308-09; Ferdon, 1984, p. 690-91; Jones, 1991, p. 1175-77.

(3) if defendant's "conduct at the time and place is unreasonable" *and* if "the gravity of the harm outweighs the utility of the [defendant's] conduct", then the injunction is granted.

William L. Prosser, W. Page Keeton, et al., *Prosser and Keeton on the Law of Torts,* 5th ed., West Publishing, 1984, at §§ 87, 88A, at pages 620, 631 of the Hornbook edition.

Summary of torts

The reader is cautioned that the above possible torts are all hypothetical in the context of weather modification: there has apparently been *no* actual case, anywhere in the USA, in which plaintiffs in a weather modification case have won by using such a tort theory.

5. Proof of Causation

Regardless of whether plaintiff proceeds on a fault-based tort, or on a strict-liability tort, plaintiff must prove in court that defendant's acts *caused* the harm to plaintiff. Articles in law reviews and weather modification symposia agree that proof of causation is the most difficult obstacle facing plaintiffs in weather modification cases:

- "a staggering burden". (Stark, 1957, p. 706)
- "Before the courts will award damages ... in weather modification cases, they must be convinced ... that (1) the modification attempt did, in fact, alter the weather and (2) the modification of the weather was, in fact, the cause of the plaintiff's damage and that this damage would not have occurred otherwise. Because of the nature of the weather modification problem, these factors will be exceedingly difficult, if not impossible, to prove." (Johnson, 1968, p. 85)
- "Failure to prove that the defendants' actions were the legal cause of harm suffered by the plaintiffs has been the downfall of most persons seeking judicial relief against weather modifiers." (Davis, 1974, pp. 412-413)
- "Failure to demonstrate the linkage between conduct of the defendant and harm to the plaintiff's property remains the major impediment in litigation involving hail suppression and other types of cloud seeding." (Davis, 1977, p. 40)
- "probably be a futile effort with his insurmountable proof problems." (Kirby, 1978, p. 60).
- "With only one exception [i.e., *Southwest Weather Research,* which was a request for an injunction, *not* a tort case], plaintiffs to date have been unsuccessful in bearing that burden" of proving causation. (Ferdon, 1984, p. 686) "... plaintiff's seemingly impossible burden of proving causation ...." *Id.* at 698.
- "The primary reason plaintiffs have failed in court is that it is difficult, if not impossible, to prove causation." (Jones, 1991, p. 1169)

An attorney wrote in 1978:

> Each storm system is individual, and it is impossible to ascertain the effect of any modification effort for the very simple reason that a cloud cannot be unmodified and modified at the same time.

William A. Thomas (1978, p. 119).

A law student, writing in 1984, commented that:

> Despite satellites, computers, and technical wizardry, it is impossible to predict exactly how much rain will fall in a given area at a given time, even under normal, unmodified conditions. .... Because it is impossible to predict exactly how much precipitation a given cloud would produce in the absence of seeding, it is equally impossible to measure the effect of seeding.

Ferdon (1984, p. 683-84).

In my opinion, these authors were wrong to declare the "impossibility" of such proof. Proof in tort litigation does not need to be absolute, but only to convince the jurors that the defendant caused the harm is more likely (i.e., probability greater than 50%) than the defendant did not cause the harm. Such a proof should be technically possible. Nonetheless, past cases in the USA show that plaintiffs have not been able to prove that cloud seeding caused his/her harm. There are several reasons for this apparently insurmountable problem of proving causation:

1. In cases during the 1950s and 1960s, scientific research had not yet progressed to the point of being able to prove causation. Problems proving causation in old cases does not necessarily imply that current cases will also fail.

2. Evidence that proves causation will involve atmospheric physics (e.g., thermodynamics of water vapor, liquid water, and ice) and statistical analyses of cloud seeding experiments. Such evidence will be incomprehensible to jurors and judges, because they are ignorant of both physics and statistics. (Incidentally, this is a common problem in tort cases involving science, technology, or medicine. In my opinion, courts in the USA have not yet found a satisfactory way of handling scientific evidence. Indeed, courts in the USA avoided evaluating scientific evidence until the landmark June 1993 U.S. Supreme Court decision in *Daubert.*)

3. Scientists who are experts in weather modification may be more sympathetic to the defendant cloud seeder than to injured plaintiffs, so it may be difficult for plaintiffs to find credible expert witnesses to testify on their behalf.

4. Cloud seeding produces a small perturbation (e.g., perhaps 10% extra rainfall as the result of cloud seeding) of a phenomena that has much larger natural fluctuations. Without a complete understanding of the physical processes in the cloud and measurement of all relevant parameters, one can not accurately predict the effect of cloud seeding on a single cloud. Because we lack this complete understanding and because we lack adequate data, we can currently only know the effect of cloud seeding by statistical comparison of large numbers of seeded and unseeded clouds. However, attorneys for the defendant cloud seeder will likely

> object to statistical evidence and demand only evidence that is restricted to the actual cloud(s) involved in the case.

In cases where plaintiff alleges that cloud seeding caused a flood from one particular cloud, problems with proving causation prevent plaintiff from succeeding in tort. The only way that I see for plaintiffs to make such a proof is, at the time of the rain that causes the flooding, to collect rainwater in special bottles that are free of metallic impurities, then later (i.e., after a damage claim) have that rainwater analyzed in a chemical laboratory that can detect concentrations of silver[18] in rainwater as small as 0.01 nanograms/cm^3. Collection of such evidence by flood victims is *im*practical. However, it would be practical for technicians at a government agency to collect such rain samples routinely during cloud seeding programs. A government regulation or statute might specify the collection of such samples, and the retention of the samples for, e.g., at least two years after each rainfall.

In cases where plaintiff alleges that cloud seeding caused a drought, there may be statistical evidence that may be useful to plaintiff. Scientific research involving hundreds of clouds, half of which were randomly chosen to be seeded, the other half of which remained in a natural state, have provided statistical evidence of the effect of cloud seeding. However, such evidence is very difficult to explain to juries, attorneys, and judges, because of the sophisticated mathematics involved in the hypothesis testing.

inconsistent position of cloud seeders

William A. Thomas (1978, p. 120) mentioned that commercial cloud seeders in the past have been inconsistent in their statements. When advertising their services, cloud seeders claim to be able to enhance rainfall. But when plaintiffs sue them for causing excessive rainfall, the cloud seeder denies that the seeding caused the excess rainfall. A similar observation was made by Stark (1957, p. 707, n. 24). And a science journalist noted:

> 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.

(Carter, 1973, p. 1348).

The attorney defending a company that hired a cloud seeder in *Adams v. California* was faced with the problem that his client's own analysis showed that the cloud seeding caused a 20% increase in rainfall. When plaintiffs who had been harmed by a flood allegedly caused by the

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[18] I assume that the active ingredient in the cloud seeding was AgI crystals. Other cloud seeding materials might be more difficult to trace.

cloud seeding cited this 20% figure, defendant's attorney discredited his own client's work by arguing that his client was ignorant of proper statistical analysis.[19]

A skillful litigator for plaintiffs, may be able to exploit this inconsistent position of cloud seeders, to destroy the credibility of cloud seeders in a trial.

6. Need alternative to tort litigation

The requirement to prove causation in tort litigation was (and may still be) an insurmountable obstacle for plaintiffs. It is *in*equitable to modify weather to benefit some people, but not compensate those who have been harmed by the modified weather. If burdens of proof from traditional tort law (e.g., the problem of proving causation) are insurmountable obstacles to such plaintiffs, then legislatures (or judges) need to develop alternative ways of compensating injured plaintiffs.

For example, the statutory law may evolve to specify that *only* the state or federal governments could initiate weather modification activities, although private cloud seeders might do the actual work under contract to the government. Such an approach would recognize that weather is part of the natural environment (also including land, water, and air) and any attempt to modify the environment should be controlled or regulated by the government.

A governmental agency that contracted for the weather modification could also compensate landowners who were harmed by the modified weather. This agency could tax landowners who would benefit from increased rainfall (e.g., a tax of a few cents/acre of land) and use that money specifically to (a) pay for the weather modification and (b) compensate landowners who were deprived of rainfall or who suffered a flood. Such an agency could compensate injured landowners according to a formula in a regulation or statute, without proving causation according to traditional tort law. This agency would have many advantage over traditional tort law: reduced legal fees, no delays in courts, and no requirements for proving causation that genuinely injured plaintiffs can not meet.

In such an arrangement, the cloud seeder would be an innocent agent of the landowners who received the enhanced rainfall. Such a legal position would be analogous to *respondeat superior* (i.e., ordering the employer, not the employee personally, to compensate the victim for a harmful act within the scope of employment). Unless the conduct of the cloud seeder was either negligent or reckless, it seems *in*appropriate to me to hold the cloud seeder legally responsible for modified weather that benefits some people and harms other people.

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[19] Morris, 1968, pp. 164, 176-77, 179; Mann, 1968, pp. 705, 710.

The amount of rainfall naturally varies from year to year, so there is no injury to plaintiff if the actual rainfall is *slightly* below the long-term average (i.e., the 50%tile) amount. For that reason, perhaps the plaintiff in a drought case should be compensated only for monetary loss resulting from the difference between the 25%tile rainfall (i.e., the amount that is exceeded in three out of four years with unmodified weather) and the actual rainfall. This proposal helps prevent the defendant from compensating plaintiff for effects of the variability of naturally occurring weather, for which defendant is *not* responsible, and for which plaintiff must assume the risk. My proposal for the 25%tile value as a boundary was arbitrarily chosen, only for use as an example in this essay. The boundary actually used should be determined by a legislative committee that writes a statute that establishes the rules for compensating those who are harmed by weather modification.

insurance

Alternatively, landowners could purchase insurance against drought and floods. The insurance company would compensate those harmed by either natural or modified weather, similar to no-fault insurance for automobile accidents. In situations where the insurance company had paid a large amount for claim(s) and the insurance company suspected negligent or reckless conduct by cloud seeders, the insurance company could sue the cloud seeders under the right of subrogation in the insurance contracts. Such a use of insurance has several significant advantages for landowners over tort litigation:

- would also compensate landowners for harm from unusual natural weather (a drought has the same effect on the landowner, regardless of whether the drought is naturally occurring or the result of modified weather);
- remove the need for landowners to prove that a cloud seeder caused the drought or flood;[20]
- solve the problems associated with class-action litigation by landowners that was discussed above in the *Lunsford* and *Saba* cases.
- spread the costs of litigation over all who pay for insurance, instead of concentrating the costs of litigation on plaintiff(s).

7. Need to Support of Basic Scientific Research

Many of the problems with the law of weather modification are attributable to our lack of basic scientific understanding of how clouds produce rain, and how cloud seeding modifies processes in the cloud.

While the need for increased financial support for basic scientific research is an important issue of public policy that faces legislators, that issue is not, strictly speaking, part of the law of cloud seeding. Therefore, I moved the discussion of financial support for scientific research from

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[20] See above, beginning at page 25.

an earlier version of this essay to a separate document,[21] to shorten this essay on the law of cloud seeding.

Only *after* the applicable scientific principles are understood can we have a rational application of law to weather modification, such as determining in tort litigation if a cloud seeder caused a flood or drought, or determining if a cloud seeder was negligent. Good laws and good regulations can not be based on possibilities and conjectures. Scientific proof that a weather modification technique is both safe and effective should occur *before* a government grants a permit for an operational weather modification project that uses that technique.

8. Property Rights in Water from Cloud Seeding

This essay has focused on injunctions prohibiting cloud seeding and tort liability for cloud seeding (e.g., either causing a drought, causing a flood, or otherwise interfering with the use of plaintiff's land) because those are the subject of *all* of the past court cases in the USA on weather modification and because I am interested in tort law and equitable remedies (e.g., injunctions).

However, there is another legal issue in weather modification that has apparently been ignored by everyone, except one law professor, Ray Jay Davis. This neglected legal issue is to answer the question of who owns the right to use the extra water that is produced by cloud seeding.

In the western USA, there are attorneys who specialize in the complex area of water rights, which is a subset of property law. Because I am not personally knowledgeable about water rights law in the various states, I choose to avoid summarizing those laws here.

When encountering new issues in law, attorneys try to find an analogy to issues for which there is well-settled law. A law student suggested[22] that clouds were analogous to wild ducks who flew over the land. Prof. Davis later suggested[23] that clouds are “rivers flowing through our skies”. The remark about “rivers” is not poetic, but is an analogy with well-established legal rules for ownership of water in rivers.

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[21] Standler, “History and Problems in Weather Modification,” http://www.rbs2.com/w2.htm , Dec 2002.

[22] Brooks, 1949, p. 119.

[23] Davis, 1968, p. 104.

unjust enrichment of nonpayers?

One could envision this issue arising in the context of a cloud seeder who is paid by farmer A to increase the rainfall on A's land. Extra rain [also] falls on land owned by farmer B; B's land is perhaps adjacent to A's land, or at least near A's land. We recognize that B has received a benefit from the extra rainfall, for which B paid nothing. From one point of view, B has been unjustly enriched. If a judge accepts this unjust enrichment argument, who should B pay: the cloud seeder (who caused the extra rain) or partly reimburse A for hiring the cloud seeder? The answer to that question might depend on who owns the right to use the extra rainfall. In defending himself, B might argue that he never requested the benefit: the extra rain was an unsolicited gift to B. And B might also argue that any rain falling on his land was his to use, an argument that is obviously correct prior to the invention of cloud seeding technology, and *might* continue to be correct. From the viewpoint of economics, B is a "free rider": B received a benefit from which someone else paid the entire cost, including any potential liability for negligence, etc. Without answering the interesting question about who owns the right to use the extra water, the obvious solution to this kind of problem (as well as many other potential problems) is to have the government regulate all cloud seeding and to tax *all* landowners in the target area, so that every potential beneficiary pays.

While experts on water rights law[24] have speculated about the legal rights of cloud seeders to use the extra water that they produce, it seems to me that there is a simpler solution that requires no new law. After receiving a permit to modify weather, the cloud seeder has a legal right to attempt to modify weather, but the right to use any extra water belongs to the landowner on whose land the extra precipitation falls. My proposal treats the cloud seeder by analogy to many other professionals (e.g., investment advisers, surgeons, dentists, engineers, etc.) who are paid for their services (i.e., making a "best effort"), but any benefits and ordinary risks of those services belong to their clients. However, the cloud seeder, like other professionals, remains responsible for any negligence or recklessness in performing services.

deprivation downwind from cloud seeding?

A more complicated problem is that of the deprivation of rainfall downwind from where cloud seeding has enhanced rainfall. The downwind atmosphere (clear air and clouds together) obviously has less water content as a result of the greater rainfall upwind, hours, or a day, earlier. *If* landowners have a legal right to receive the naturally occurring rainfall, then downwind landowners have been deprived of rainfall.

From the viewpoint of atmospheric physics, such concerns seem trivial. Clouds are not efficient at producing rain or snow: most of the water (or ice) in a cloud does *not* reach the ground during that one shower or snowstorm. Even after a vigorous rain shower, thunderstorm, or

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[24] Davis, 1968, p. 112; Beck, 2001, p. 3-22.

blizzard, most of the original cloud remains in the sky. A meteorologist explained for orographic clouds:

> In a typical precipitating cap cloud about 20 percent of the water vapor in the upwind air mass (which we shall assume is cloud free) condenses. Of this, about 20 percent falls out as precipitation. Therefore, 100 (0.20 x 0.20) = 4% of the water vapor is removed. If cloud seeding increases the precipitation by 10 percent, then the water vapor is depleted by an additional 100 (0.10 x 0.04) = 0.4%, a relatively small figure.
>
> The argument is quite valid and has been used for many years to explain that a rather trivial reduction in total water would occur in the area downwind of a target area. ....

Elliott, 1974, p. 61.

From this viewpoint, the deprivation of rain suffered by downwind landowners is *de minimis,* a harm that is too trifling to be compensated (i.e., *De minimis non curat lex.*). Alternatively, the computation of the amount of damages will be speculative, and thus too uncertain to permit a court to order compensation, because the plaintiff is not likely to have data on the amount of water that was wrongfully removed by cloud seeding and that would have otherwise have fallen on plaintiff's land.

In a few days, some of the rainfall from previous cloud seeding will have evaporated and contributed to a new cloud, thus renewing the cycle of water in the atmosphere. The new cloud will be larger as a result of the evaporation of the enhanced rainfall that was caused by previous cloud seeding. I wonder if the legal concern about downwind deprivation of rainfall would be better cast as a *delay* in downwind rain. If the delay is only a few days, such harm would be *de minimis.*

Davis (1968, p. 116) suggested that, to restore the deprivation, cloud seeders also seed clouds downwind from the first target zone, but that remedy only pushes an increased deprivation further downwind. Again, the obvious solution to this kind of problem — as well as many other potential problems — is (1) to have the government regulate all cloud seeding and (2) to have either a government agency or private insurance compensate landowners for below average rainfall.

A leading treatise on water rights law in the USA says:

> Does intervention mean taking rain from someone else further down the cloud drift? Scientists appear to say no, but lay persons do not believe readily, and therefore the threat of litigation has to be considered.

Beck, 2001, p. 3-12.

This reaction by laymen is one of the most exasperating features of making public policy about science or technology. Laymen will form a personal opinion, even a strong belief, without any rational reasons to support their opinion. On the other hand, scientists ideally form opinions after considering all of the relevant facts and theories, including measurements and calculations.

9. Conclusion

It is clear that man already has the technology to modify weather and that more effective technology can be designed. However, we need scientific knowledge to understand how and when to use such weather modification technology, so that intelligent choices can be made, instead of guesswork. Civilization would immensely benefit if damage from drought, floods, hurricanes, hail, tornadoes, etc. could be reduced. But before we reap such practical benefits, we need much more long-term financial support of basic scientific research on weather modification by the government.

Despite the potential immense economic importance of cloud seeding and the existence of commercial cloud seeding technology since 1950, the courts in the USA have *not* yet begun to resolve legal issues involving either negligent cloud seeding or the rights of landowners to rain from the clouds that are either above their land or upwind from their land. I have been able to find only eleven court cases in the USA on cloud seeding (all decided during 1950-1987), and no cases since 1987.

After reading all of the reported court cases in the USA on this topic, I conclude that states need to create a government agency to compensate people who have been harmed by weather modification,[25] or, alternatively, landowners need to purchase flood/drought insurance.[26]

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[25] See page 28, above.

[26] See page 29, above.

10. Bibliography

In addition to the cases cited above, beginning at page 5, the following articles in scientific or legal journals and the following books may be of interest. Because this essay will be of interest mostly to nonattorneys, I have used a standard academic citation format, instead of the customary legal citation format.

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About the author

I took several classes in atmospheric physics during 1971-76, while I was a student in graduate school, although my emphasis was in general physics. My first peer-reviewed scientific publication was a paper that reviewed the published literature on the toxicity of silver iodide used in cloud seeding. I did scientific research in atmospheric electricity and lightning during 1971-79 and earned a Ph.D. in physics in 1977. The drastic decrease in the U.S. Government's financial support for basic scientific research in atmospheric electricity caused me to change fields in 1982 from basic scientific research to practical engineering research on protection of electronic equipment from transient overvoltages, such as caused by lightning. When financial support for research in all of my areas of science and engineering was annihilated in 1990, I began to change careers to law. Since 1998, I have been an attorney in Massachusetts and a nationwide consultant to litigators on scientific evidence in torts.

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