WEATHER MODIFICATION, DROUGHT, AND PUBLIC POLICY: A CASE HISTORY[1]

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Abstract. Drought is a recurrent problem and water scarcity a worsening dilemma in some of the fastest growing parts of the United States. As weather modification tends to be used in conjunction with drought, there is need for policy which embraces weather modification and drought. But what is such policy to be? Who is to say? And how is it to be formulated? To help answer these and related questions, a case history of recent attempts by Colorado to deal with the interplay of weather modification and drought has been prepared. This study highlights not only a problem in weather modification and drought, but issues at the intersection of atmospheric science and public policy generally. A drought is not the most propitious time to apply weather modification techniques, or make long-term policy. But, the time immediately following a drought may be an optimal time to get policy improvements for weather modification and drought on the governmental agenda, thereby turning a period of recovery into one of long-term policy preparedness.

1. INTRODUCTION

One of the ironies of weather modification and drought is that the political requirements that make weather modification's use most likely collide with meteorological realities that minimize its utility. Droughts present relatively few opportunities for seedable clouds. A technology based on cloud seeding is obviously limited. Yet drought periods are just the times when the demand to use weather modification is likely to be greatest. The pressure for emergency programs can be enormous. Frequently, the junction of political and scientific reality serve neither the interests of weather modification nor those of drought mitigation. The technology is perceived as ineffective and the problem is not alleviated.

Drought is a recurrent problem and water scarcity a chronic and worsening dilemma in some of the fastest-growing parts of the United States. There is a need for policy which embraces weather modification and drought. But what is such policy to be? Who is to say? And how is it to be formulated? To help answer these and related questions we have studied intensely the efforts of one state, Colorado, to deal with weather modification and drought. The story of one state is hardly the story of all states, much less national policy in general. However, it does highlight issues in weather modification, drought, and the intersection of atmospheric science and policy making. A drought may not be the most propitious time to apply weather modification techniques or make long-term policy, but the period immediately following a drought may be an optimal time to get policy improvements for weather modification and drought on the governmental agenda. Also, our study of Colorado points up the fact that the period for long-term policymaking aimed at preparedness is relatively brief. Return to perceived "normalcy" in weather means normalcy in politics for weather modification and drought. For weather modification, this means controversy; for drought, this generally means apathy. Neither promote rational decision-making.

The dynamics behind this circumstance are rooted in "who" is active "when" in weather modification and drought. The policy participants change over time and, quite literally, "fall" in the policy hierarchy as time passes. Political leaders are active at one point, top administrators at another, and scientists on the technical level at still another.

In considering the recent situation in Colorado, we have organized our information in terms of a sequence of events (or stages) surrounding and following any major drought experience. Initially, there is the onset of the drought. Then comes the response to drought. This is followed by the recovery period. Finally, there is normalcy--or the perception of normalcy.

Recovery can mean simply an effort to go back to where the affected area was prior to the drought. Or, it can mean a special effort to mitigate the problems revealed by the experience--to "do better" next time. In that

case, recovery can be akin to preparedness. Or perhaps preparedness can be called a stage between recovery and normalcy. Either way, it is potentially a critical period for policy innovation in weather modification and drought. The Colorado experience is important because it illustrates a situation in which there was an effort, at least at a preparedness stage.

Overall, this case history covers the period 1976-1985. Changes in weather and climate are paralleled by changes in the nature of policy, and in who influences the process. Weather and policy do interact. One impacts the other. They do so over stages that are roughly separable. As the issue falls in public prominence, it becomes less one of concern to policy makers, and is sustained by interests at the scientific and technical level. Those at the technical level--the scientific community--who wish to influence policy must do so during these brief preparedness stages. These are "windows of opportunity," when the politicians are listening. Usually, that is when the drought and the problems it caused them are still on their minds.

2. ONSET

As winter arrived in 1976, it became gradually obvious that Colorado and much of the western United States was entering into a period of drought. Colorado is a semi-arid state, with less than 14 inches of precipitation in an average year. Much of this precipitation comes in the form of snow. A winter drought for Colorado thus could be a major disaster for the state. Not only could it impact on agricultural and ranching interests, but also on the state's important ski industry. It was representatives of these economic interests who alerted Colorado policymakers to the seriousness of the drought, and need for governmental action (Sherman, 1980).

On December 28, 1976, Governor Richard Lamm requested the U.S. Secretary of Agriculture and the President to declare 16 Colorado counties as agricultural disaster areas. "The governor's request was predicated upon an Agricultural Stabilization and Conservation Service (ASCS) report that showed significant crop and livestock losses in the counties for which the declaration request was made" (Gray, 1979, p. 23).

The drought grew worse in January. Ski resorts were suffering. On January 19, 1977, the governor held a cabinet meeting to discuss the crisis. At the cabinet meeting, the Division of Disaster Emergency Services (DODES), of the Department of Military Affairs, was charged with identifying the probable impacts of drought in Colorado and assessing the capabilities of state agencies to address these impacts. The use of weather modification as a possible mitigation option was discussed, but no decisions were made.

Three days later, on January 22, a Saturday, the governor met at his mansion with his Advisory Council on Science and Technology and numerous experts from within the state who were knowledgeable about drought and weather modification. Both the problem and the possible responses were discussed. There was general agreement that water conservation was fundamental. In addition, means of augmenting supply were considered, among them being weather modification. There was a general feeling that weather modification was no "solution," but that it might help. The issue was how much?

On January 25, shortly after this discussion, Lamm made it known that he had decided to proceed with weather modification (The Leadville Herald Democrat). A few days later, armed with a quickly developed proposal for an emergency weather modification program, the governor met with legislative leaders. He told them this would be the first step in a three-year weather modification program. It would cost $150,000 to fund seeding in three key areas of the state. The areas expected to be part of the proposal included the San Juan Valley, the Climax-Leadville area, and the northern Rockies. The governor emphasized that steps had to be taken immediately because there were no signs the drought was going to end.

On January 31, a bill appropriating nearly $190,000 in state funds for an emergency cloud seeding program was introduced in the Colorado House. The bill set aside $189,200 for a proposed $251,200 plan to seed clouds to stimulate snowfall in four areas of the state. The remaining $62,000 was to come from local water conservation districts, the U.S. Bureau of Reclamation, and the City of Aspen. After its hearings, the committees voted favorably on the bill. There was practically no opposition at this time.

Thus, on February 2, Western Weather Consultants began applying for permits in proposed seeding sites. Before administrative hearings on the permits could take place, the Colorado Senate acted on the bill.

On February 4, the Senate voted favorably, 26 to 3. The same day, the House accepted a minor amendment and voted in favor, 52 to 5. Still that same day, the bill went to the governor and he signed it into law, in a form essentially as he had proposed. The legislation not only provided funds

($251,200 for seeding, $30,000 for evaluation), but also made it clear that the state, its officials, and employees were immune from liabilities resulting from weather modification actions approved or conducted by them (LeCompte and Grant, 1977).

3. RESPONSE

With the signing of legislation, implementation was officially under way. The legislation placed Department of Natural Resources (DNR) in charge of the program. The director, Harris Sherman, had sensed a conflict of interest with his role as the state's chief regulator of weather modification. Hence, he had delegated the responsibility of running the program to a semi-autonomous subunit within DNR, the Colorado Water Conservation Board.

By the second week of February, the permit process was completed for Western Weather Consultants and another Colorado-based cloud seeding firm, Colorado International Corporation. Colorado State University (CSU) now entered into agreements with Western Weather Consultants and Colorado International, as subcontractors, to plan, oversee, and manage the actual seeding. The state authorized the program to begin at the first seeding opportunity after February 15. As of this time, when seeding commenced, approximately 70 percent of the snowpack season had passed. The governor, nevertheless, was pleased to see implementation start. It was not just the added snow; it was also the political effect. On February 21, Lamm declared that: "In politics movement is action," and cloud seeding is "a way to dramatize to the people that there was a drought" (LeCompte and Grant, 1977).

As the program evolved in ensuing weeks, problems in administration and communication surfaced and were worked out as best as possible. One of the issues that was a continuing difficulty arose from the fact that Colorado International received its forecast from another private firm, Geophysical Research and Development, rather than having "in-house" forecasting. This made consultation with CSU on the daily meteorological situation awkward, since Colorado International did not have forecast materials on hand during the daily discussions. This resulted in two forecasts and occasional differences of opinion regarding future operations (LeCompte and Grant, 1977).

Another issue was the ill-defined responsibility with respect to the seeding program (LeCompte and Grant, 1977). Perhaps the most intractable issue concerned the question of whether or not the program was effective in producing more snow. The media's thirst for immediate (and newsworthy) statements about the weather modification program produced premature (and possibly unwarranted) optimism from the governor and seeders. This bothered CSU scientists, but there was little they could do about the situation.

While CSU and the private seeders were dealing with the program of 1977, there were others who were worrying about what to do if the drought continued the following winter. As early as March 29, the Drought Council--a high level policy advisory body to the governor--discussed what to do about next year. Sherman commented at this meeting that the existing activity had not yet been evaluated and, hence, its results could not be determined. Although a budget for a second year's seeding could be formulated, he felt the need to first evaluate the effectiveness of the ongoing program before making recommendations for a follow-on effort (Drought Council, 1977).

On April 7, George Lamb, the governor's specially designated drought coordinator, wrote to Sherman: "The need for legislative consideration in this session is self-evident; a complete program has planning and execution requirements which occur in the late summer and fall, long before the next legislative session."

On May 15, 1977, the weather modification program came to an end. Lewis Grant, the Colorado State University scientist in charge of the project, was quoted as estimating that the seeding increased snowfall 13 to 19 percent over what it would have been without seeding. As for continuing the program, he was clear that it should be run the following winter (Lang, 1977).

Meanwhile, Governor Lamm had been lobbying with other western governors to get federal assistance for state drought response activities. On May 4, 1977, these efforts were rewarded when President Jimmy Carter signed legislation providing several million dollars to western states in emergency drought relief. Much of this money was relatively flexible in the sense that it could be used in accord with a specific state's needs.

On May 20, Lamb sent Drought Council members a first draft of state legislation for both an overall drought program and a special weather modification element. This weather modification activity was by far the most expensive (Gray, 1979). Once again, the legislative process moved swiftly, and the governor got essentially what he proposed. On June 10, Lamm signed the second weather modification bill into law, thereby authorizing $350,000 in state funds. At the same time, a com-

panion bill was signed into law appropriating $46,000 to the Office of State Drought Coordinator. This bill also provided a statutory base for the Drought Council and set membership.

The second year's program was planned to be far larger than the first. Due to the increased size of the second weather modification operation, the state contracted with a member of CSU's Department of Atmospheric Science to work full-time at the Water Conservation Board implementing the program, rather than splitting time between weather modification and university duties. On October 12, the Federal Bureau of Reclamation approved a request from the Water Conservation Board for an additional $600,000 for state weather modification, bringing total funding for the second year winter cloud seeding program to $950,000.

The weather modification program ran smoothly as the winter began. The major concerns expressed at the Drought Council meeting were not with the Colorado program, but rather with the fear that seeding programs of other states might interfere with the one Colorado was running.

At the beginning of December, it appeared to those involved in the seeding program that they were having a considerable impact. At the time permits were issued, lack of snow was the problem. In early December, however, the snows began to fall harder and more constantly over the Rockies.

On December 5, the seeding generators were shut down. Under the permits, seeding had to stop when snowfall topped 200 percent of normal as of January 31. There was no state order to shut down, but those operating the program felt they were getting very close to excessive snowpack and wanted to check the situation. It was indicated that the program definitely would continue in certain areas, while being placed on hold in others. By the turn of the year, 1978, Colorado had plenty of snow in its mountain areas and considerable business for its ski resorts. There were few alarms now being sounded by farmers, who anticipated enough water in the spring from run-off.

Optimism was growing that the drought was ending. Governor Lamm, who was receiving meteorological advice, was not yet ready to say the drought was history. Yet it was difficult for legislators and others to think about lack of precipitation when the snows continued to be heavy through January and February.

4. RECOVERY

In March 1978, those involved with the program began asking about next year. There was still a Drought Council and state drought coordinator, and there was cautionary rhetoric from the governor in his State-of-the-State address. There was the fact that, when the governor had first broached the subject with the legislature in January 1977, he had spoken of the need for a three-year effort. But time had passed and so had the drought, for most of the state.

The legislator who had sponsored the original cloud seeding bill was willing to introduce legislation to keep the weather modification program going. In mid-March, he authored a bill to continue the winter cloud seeding program another year at a cost of $250,000. However, he found that the governor was apparently less interested. The governor's closest advisers reportedly saw the program as an emergency measure, and did not wish to continue the same type of effort under non-drought conditions. The bill was allowed to die.

On April 30, 1978, the state-run weather modification program officially came to an end. The Drought Council and some drought operations other than weather modification continued through the summer, but Colorado was recovering. By fall 1978, virtually all drought-related activities ended, and the state drought program officially ceased to be (Gray, 1979).

5. PREPAREDNESS EFFORTS

In the wake of the drought, there was stronger realization on the part of various Colorado leaders that the state was extremely vulnerable to climatic variability. There was talk about the need for a state policy that would anticipate future water problems and prepare the state for the time when those problems were exacerbated by drought. There were those who recalled a severe drought in the 1950's, the repeat of which could be horrendous in a state far more developed, populated, and thus possibly vulnerable.

For some, preparedness included weather modification as a potentially useful tool. For others, weather modification was the one tool they did not want used. For still others, weather modification was not yet a "tool," in any reliable sense. The possibility of policy action brought reaction. All the traditional debates surrounding weather modification, muffled in the onset stage, virtually absent during emergency response, now began being heard as the recovery period phased into a debate about the role of weather modification in long-term preparedness.

Thus, an active political process focused around drought, weather modification, and preparedness for long-term water scarcity was ensuing. It had been triggered by the experience of drought. Those who most keenly felt the need for

a positive state policy for cloud seeding were a number of existing large weather modification users. These included the ski industry, certain segments of the agricultural industry, and major municipal water suppliers, such as the Denver Water Board. They were disappointed when the state decided against a third year of state-sponsored seeding.

Seeding did continue, however, under private and non-state auspices. Opposition arose from certain San Luis Valley interests. They complained to the state legislature about "illegal" seeding in their area, seeding they perceived to rob them to benefit others. Sympathetic legislators responded by proposing and eventually passing a law imposing harsher penalties on those caught seeding without a permit.

On January 18, 1979, Sherman temporarily halted the "legal" private cloud seeding program underway in mountain ski resort areas. He stated that there was so much snow falling that there might be hazardous conditions. Harris said several problems had surfaced in the previous week. One involved avalanche dangers as outlined by the State Highway Division. Another came from the Division of Wildlife which indicated the heavy snows were creating hazards to wildlife ("State Calls Halt to Cloud Seeding," 1979).

A month later, the seeding halt became an indefinite suspension, as it became clear that a record snowpack was developing in Colorado and there could be danger of floods when the run-off began in the spring ("State Authorities Fear Floods, Halt Seeding Indefinitely," 1979).

Summer 1979 came and San Luis Valley farmers and ranchers continued to complain that there was illegal seeding taking place. By fall 1979, the state was feeling pressures not only from differing weather interests within the state, but also from federal sources. The U.S. Bureau of Reclamation (BuRec) was raising the possibility of a multi-year, multi-million dollar demonstration project in mountain winter seeding. BuRec's interest was in augmenting run-off to the Colorado River, an interstate river of huge significance to the southwest. BuRec had been authorized to plan a demonstration by Congress in 1977, a time when the western drought made Washington more receptive to such a large-scale activity (Silverton Standard and Miner, 1979).

Now, in 1979, with planning underway, BuRec was beginning to press Colorado for cooperation. The state government was cautious, seeing benefits to other states, with impacts being felt in Colorado. Meanwhile, the intrastate debate over weather modification and drought, and potential drought, was growing more heated.

The polarization was symbolized by a confrontation between the Colorado Cattlemen's Association (anti-weather modification) and a coalition of weather modification users. DNR avoided taking sides, and said the state was attempting to settle the many major issues affecting the subject of weather modification, including issues involving use of the technology in drought versus more "normal" situations (Johnson, 1979.)[4] In mid-December 1979, DNR called an informal meeting of various legislators, representatives from Denver Water Board, the Northwest Colorado Conservancy District, and several members of the State Advisory Committee on Weather Modification. Sherman told those he assembled that he was getting increasing complaints from many sources in affected areas about private weather modification. It was not just the cattlemen. Those attending agreed that new legislation was needed. The alliance of users had grown to 22 major entities. Each had contributed $1,000 to an effort by Western Weather Consultants to draft a state program (Western Weather Consultants, Inc., 1980).

On January 31, 1980, DNR filed legislation. It was modeled in one respect on the program proposed by the user interests. In another respect, it was quite different from what they wanted and in line with what their opponents demanded.

Thus, the bill called upon the state to sponsor a $1.4 million research and evaluation program of winter snowpack augmentation. The program would extend seven years. However, the bill also called for a halt of all commercial operations during this seven-year period. Where necessary (e.g., drought), operational programs could be run. But these would be under state control and sponsorship.

The DNR bill made weather modification a state monopoly for a period of seven years. The emphasis would be on resolving issues, rather than enhancing snow for its own sake. The moratorium on private seeding would hopefully also keep down controversy, so the state could concentrate on fundamentals.

In mid-February 1980, Sherman left DNR to go into private law practice. With Sherman's departure, much of the push behind the bill went. As policy momentum diminished, opposition to the bill grew. The bill went to the House Appropriations Committee where it died in spring 1980 (Welles, 1982).

Colorado had enjoyed another good snow year. The debates over weather

modification policy had taken place in a context of diminishing urgency about precipitation problems. Those public and private interests who wanted legislation were not aided by weather and climate. Nor were they helped by their own lack of unity.

The same user forces who had pushed for a state weather modification program in 1979-1980, and who had seen their views amended by DNR in ways they could not tolerate, were ready to try once more in 1981. Their interest was, again, in a long-term state program involving research, demonstration, and evaluation to advance the technology. Private seeding, however, would continue because its members had a continuing need. DNR agreed to go along with their position this time.

On February 17, 1981, a bill was introduced that reflected a compromise between the weather modification users and previous DNR position. The program was to commence during the winter of 1981-1982 and be completed no later than June 30, 1988 (Welles, 1982). The previous requirement for a moratorium on private seeding was omitted. The bill was amended in the legislature and the appropriation reduced from $650,000 per year for seven years to $325,000 for each of the seven years, with an equal amount ($350,000) to be raised from other sources before any of the appropriated funds could be spent. It was also amended to read "no other weather modification projects that could affect winter storms shall be carried out in the state of Colorado during the period that such research and demonstration program is in progress."

In this form, the bill was passed by the substantive committees and sent to the House Appropriations Committee. By April 1981, it was clear that the Appropriations Committee was not going to move the bill forward. The reason was now due to a serious state budgetary problem and desire to avoid any new programs. Whatever opportunity weather modification might have had earlier was not there in 1981.

Partial progress in drought planning

Weather modification and drought were linked in the response period, and, in the minds of many, during the recovery/preparedness phase of policymaking. However, in the interest of some progress, there were others who saw it best to "unlink" the two. After all, there was much that could be done to better prepare for drought that had nothing to do with weather modification.

This, apparently, was the view of the governor, who had let DNR take the lead on weather modification. On February 5, 1981, stimulated in part by relative lack of snow in the early winter, he asked the director of the DODES to coordinate an interagency planning effort specifically on drought. He ordered that there be provided, within 90 days, a plan for an improved method of decision making for drought. If Colorado was to be subjected to drought on a recurrent basis, the governor felt it should develop a standard operating procedure, rather than react through crisis decision making.

On May 15, a plan prepared by the interagency task force was completed and sent to Governor Lamm, who adopted it as policy the following day. Under this plan, there would be two distinct administrative systems that would operate in tandem to support the state government's response to drought. One system would supervise the assessment of drought conditions and the other would manage the state's response.

The administrative groups would be composed of state and relevant regionally-based federal agencies. They would focus, in terms of response, on municipal water, wildfire protection, agriculture, commerce and tourism, wildlife, the economy, energy, and health. Specific methods of drought mitigation, such as cloud seeding, were not designated. While not a prediction system per se, the assessment mechanism that was set up was seen as a potential early warning system that could make use of whatever predictive capability was available. At minimum, it would help bring together previously scattered information about water availability in the state, so the governor would have better and more current information about the status of a developing, or receding, drought. A new Water Availability Index was a tangible result of this assessment effort.

6. NORMALCY

The drought plan was adopted--and weather modification program rejected--at a time when the precipitation situation of Colorado was perceived as returning to normalcy. Normalcy meant successive years with plenty of snow.

With the Reagan administration budget cutbacks taking full effect at this time, BuRec was hard-pressed to keep ongoing programs alive, much less start the new one in Colorado it had proposed. There was now no state legislation being pressed in any serious way. It was more of the same in 1983, in the sense of bountiful precipitation and minimal policy.

There was some activity in the scientific and technical community of Colorado. Drought assessment (i.e., water availability) mechanisms continued to be developed and refined. They had

yet to be tested by a drought, however.

There was some linkage of drought planning with weather modification within the state government. However, this linkage was in the minds of individuals well below those with power to make policy. In 1984 and 1985, normalcy continued. The winter drought of 1976-78 now seemed ancient history.

7. CONCLUSION

The interplay of weather modification, drought, and public policy in the recent Colorado context has been discussed. This case points up the relation of policy to weather and climatic variation. In the absence of pre-planning, the event itself--a serious drought--tends to be greeted as a crisis and policy makers react with the tools at hand. Weather modification frequently is an option. Choices are made at the highest political levels, and they are made for substantive reasons (possible mitigation) and political effect (dramatizing action).

The window of opportunity for doing better by drought and weather modification comes in the recovery period, when "weather policy" has attention of state policymakers. The drought may be over, but it remains a recent reality and, hence, a trigger for more considered policy action aimed at preparedness for the next crisis. In Colorado, there was forward motion in drought planning, and new interagency mechanisms for assessment and possible response established. But for weather modification, the opportunity to use the recovery period for enhancing the viability of the technology as a potential tool was lost. Those in favor of weather modification could not unite, while those against the technology--relatively silent at the onset and during the drought--were extremely vocal. After a while, however, as what was perceived as normalcy returned, weather modification and drought were placed on the backburner of state decision making. Significantly, over time, the level of action involvement fell from the governor and legislature, to administrators, to scientists and technical people with substantive knowledge, but little policy authority.

8. IMPLICATIONS

While it is difficult to generalize from one case history, events in Colorado do have implications of national significance. The case reveals the large gap between those who are sensitive to the vagaries of weather and those who are responsible for policy. There is a serious problem in merging the long-term perspective of scientists and professionals with the short-term perspective of policymakers. Droughts recur. That may be true meteorological (as contrasted with political perception) normalcy.

Preparedness makes sense. Weather modification tends to be used, if only because people get desperate and politicians feel compelled to act to show they are trying to alleviate suffering. It is irrational not to develop weather modification technology so it can be a better policy option. As such, seeding could take place at the meteorologically best, rather than worst times for precipitation augmentation.

What is needed is a weather modification program that relates to long-term water development needs and extreme variations in weather, particularly drought. Such a program would have to be designed to be intergovernmental, since the federal government is responsible for research and development, and states are where the impacts (and politics) of weather modification, drought, and water scarcity are felt most keenly. States are users and potential co-developers.

The optimal time to bridge the gap between the science and public policy of weather modification/drought is in the recovery period, where some political consensus as to problem is present and those with proposals to do better next time may get a high level hearing. This is the window of opportunity for change, which can convert recovery into a potential preparedness period. It is open, but briefly. Thinking, strategy, and cooperation among concerned parties must take place prior to the next drought, however, to make the most of the opportunity when it comes.

FOOTNOTES

1. An earlier version of this paper was presented at the ninth conference on Weather Modification, Park City, Utah, May 21-23, 1984. The research was sponsored by NSF Grant No. ATM-8210146. The advice of Stanley Changnon, Richard Dirks, and Hassan Virji on the report from which this paper derived is gratefully acknowledged. The views expressed here are those of the authors, and not necessarily those of NSF or the individuals mentioned.

2. The Maxwell School, Syracuse University, and Science and Technology Policy Center, Syracuse Research Corporation, Syracuse, New York.

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4. Several matters concerned the cattlemen. These included: 1) the additional cost of putting cattle on full feed early in the season, since regular pasture land was buried in snow; 2) the costs of snow removal and building repairs; and 3) the state had authorized commercial seeding despite the protests of the cattlemen that it would have the

adverse effects it did in fact have.

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