

THE VALUE OF EXAMINING ECONOMIC IMPACTS OF WINTER CLOUD SEEDING

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Abstract. The combination of elevation, snowfall and the need for more water makes the Upper Colorado River Basin an unusually attractive area for winter cloud seeding. Political and public support, however, are prerequisites to secure seeding permits in Colorado. The state has sponsored a number of economic impact analyses designed to answer questions commonly raised about seeding. The results of these studies are summarized together with the process used to provide for citizen participation in Colorado's cloud seeding decisions.

1. WEATHER MODIFICATION AND COLORADO

The State of Colorado, site of fifty-three peaks above 4,267 meters (14,000 ft.), offers excellent terrain for winter orographic cloud seeding. Water on the western slope of the Continental Divide flows into the Colorado River. Melting snow from the Colorado mountains provides over 70 percent of the average annual Colorado River flow of 13.8 million acre feet.

Because water from the Colorado River is essential for the rapidly developing southwestern United States, the River has spawned a number of important political documents. The Colorado River Compact of 1922 apportions the river waters between the upper and lower basins; later agreements divide the water among the seven states within the two basins. An international treaty guarantees Mexico 1.5 million acre feet of water annually.

The Colorado River Basin Project Act of 1968 directs the U.S. Department of Interior, Bureau of Reclamation (BUREC), to determine the best means of augmenting the flow of the river. On March 25, 1981, Commissioner Robert Broadbent testified before the U.S. House of Representatives Subcommittee on Water and Power Resources that weather modification is scientifically possible, and promises to be the most cost effective means for increasing water supplies.

Most of the major winter cloud seeding research projects in the United States have been conducted in Colorado and the BUREC plans a major project to test the ability of winter cloud seeding to increase the flow of the Colorado River. Because impacts of snowpack augmentation in the Colorado River basin fall heavily on Colorado, the Colorado Department of Natural Resources (DNR) works closely with the BUREC to plan and conduct studies of mutual interest.

Research was conducted in Colorado during the winter of 1984/85 on the delivery of seeding materials released from aircraft and small balloons to target

areas. A small study to trace seeding materials was sponsored by ski areas. Government agencies, ski areas, water districts, municipal water providers and water conservancy districts sponsored winter seeding operations.

The state weather modification agency encourages research and, when funding is available, assesses economic impacts of snow. This research aids policy maker analysis of impacts and increases public understanding of the potential of the technology. The future of this technology is largely dependent on public awareness and acceptance of its possibilities.

2. REGULATING WEATHER MODIFICATION PROJECTS

Weather modification in Colorado is regulated by state statute administered by the DNR.

Cloud seeders must obtain a license to conduct seeding and a permit for each project. Applicants for permits are required to state the objective, dates and target areas of proposed projects. The state agency arranges public meetings in the areas where projects are proposed. The permit applicants explain the projected economic benefits, the scientific and technical feasibility and the safeguards to prevent damage.

2.1 Reducing Controversy

Public support for cloud seeding is mixed, based largely on the benefits people perceive they will receive. Before being granted a permit, applicants for commercial projects present detailed analyses of expected economic benefits and estimate the economic loss which will occur if the project is not conducted. Some organizations such as ski areas and water providers believe economic gain relative to cost is so large they view cloud seeding as low cost insurance.

Project dates may be controversial. Ski areas typically wish to start seeding in early November to ensure an adequate

base. Many ranchers believe that snow in early November makes pasture less accessible and necessitates supplemental feeding of cattle. Snow in the spring disrupts calving. In response to concerns of ranchers, the Colorado DNR usually does not allow seeding to begin in ranching areas prior to December and requires projects to end before calving season begins.

Sometimes local government officials oppose seeding because they believe seeding increases snow removal costs. Requests for compensation for snow removal probably will continue to be an issue.

3. ECONOMIC ASSESSMENTS CONDUCTED BY COLORADO

Colorado, in cooperative agreement with federal agencies, has conducted several studies of the economic impacts of snow. Such analyses are difficult to conduct because accurate knowledge of precipitation stimulated by cloud seeding is unavailable and snowfall varies greatly from year to year.

3.1 Early-Season Snow and Skier Visits in Colorado

This study assesses the effects of early-season snow on skier visits and relates skier visits associated with more snow to retail expenditures. Results indicate that skier visits to destination areas (where most visitors stay overnight) relate closely to early season snow amounts, but that visits at day areas (where most visitors do not stay overnight) do not correlate with early season snow amounts.

The study estimates the increase in annual retail expenditures in a hypothetical dry winter if early-season snow depths are increased 15 percent. Estimates range from about \$460,000 at a day area to about \$10 million at a destination area. These estimates indicate that additional early season snow in dry winters can bring a sizable influx of dollars to the economies of ski area counties.

3.2 Daily Snowfall and Skier Visits in Colorado

To understand the daily impact of snowfall on Colorado ski areas and the Colorado economy, skier visits are related to daily snowfall amounts. Results of the study indicate that skier visits and daily snowfall amounts in the mid-season do not correlate.

3.3 The Value of Electric Power and Possible Effects of Weather Modification on Small-Scale Hydroelectric Production in Colorado

This study estimates the effects of possible increases in streamflow from seeding on the production of small-scale hydroelectric power. Flow at two proposed sites

for small-scale hydroelectric production is related to the water content of April 30 snowpack. Results show that a 15 percent increase in water content raises energy output by about five percent. The conclusion is that possible increases in streamflow from cloud seeding could significantly increase the amount and value of energy produced by small-scale hydroelectric facilities.

3.4 Simulating Costs of Removing Snow from County Highways in Colorado

This study addresses concerns by high mountain communities that cloud seeding produces increased costs for highway maintenance. Procedures and estimated costs of removing snow from mountain county highways are evaluated. Most counties do not keep detailed records of equipment and labor costs. Products of this study are a computer model to simulate costs of snow removal and the recommendation that counties keep more detailed records.

3.5 Assessing the Economic Effects of Early-Season Snow on the Ranching Industry in Western Colorado

This study examines the concerns of mountain ranchers that economic loss accrues from additional snow. Almost 20 percent of Colorado's cattle are raised in areas where heavy snows and cold temperatures make ranching operations difficult. Ranchers claim that additional snow from weather modification covers rangeland in November and December necessitating supplemental feeding. Also, elk and deer damage haystacks and fences when they can't reach natural feed.

Colorado law provides payment for damages caused by wildlife. Added costs, if snow is increased, can be assessed by relating damage claims to amounts of snow. Costs incurred by Colorado to bait and feed wildlife to reduce fence and haystack losses also are available.

Interview reports for this study show that ranchers are encouraged by state interest in these problems.

4. WHY ECONOMIC IMPACT ASSESSMENT IS IMPORTANT

The Colorado DNR studies economic impacts of seeding to help determine whether weather modification is politically and socially acceptable. As the regulatory agency, however, we must seek to verify the claims of economic benefit made by permit applicants. Attempt is made to quantify economic impacts for future compensation proposals. Much remains to be done.

4.1 Future Compensation for Impacts

Some people believe that impact compensation will be required. Before compensation can occur, policy and costs must

be determined. At present, the only compensation mechanism in Colorado is the contribution of materials for repairing fences and protecting the haystacks of ranchers who claim that damage has been done by deer or elk seeking feed. Before compensation procedures for weather modification costs can be developed, there is a need to know more about how the costs relate to seasonal snow and to snow from individual storms.

It is necessary to assess how costs relate to natural snow prior to determining the economic impact of increased snow from cloud seeding. Until scientists know more about the effects of cloud seeding on snow amounts, the economic impacts of seeding can only be estimated.

4.2 Scientists and Policy Makers

Besides assessing the economic impacts of snow, the Colorado DNR encourages communication between the atmospheric scientists and the policy makers who must know their constituent's concerns. Our experience shows that a better informed public has more confidence in the regulatory process and that public understanding and support are particularly crucial to the development of the technology.

5. SUMMARY

Colorado policy makers believe weather modifiers should address the concerns of the public. The Colorado DNR considers the economic impact studies part of the legislative mandate. Citizen participation is included in the regulatory process by appointing Citizen Project Review Councils. Citizens on the councils learn about weather modification technology and inform the state about local conditions.

Besides encouraging the study of the effect of snow on Colorado's economy, state weather modification policy makers support the continued study of the effectiveness of the technology. Major subject areas needing more understanding include the transportation of seeding materials to the clouds and the effects of mountain winds on precipitation from seeding.

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