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**WEATHER MODIFICATION.** Rainmaking efforts began in Texas in the early 1890s, when army units, recalling that in the [Civil War](#) artillery bombardments often had been followed by rain, experimented by firing explosives into the air in the hope of obtaining rain. Experiments were conducted in Midland at least as early as 1891 by Gen. Robert St. George Dyrenforth, who used explosive balloons and artillery to "break the balanced state" of nature and make rainclouds develop. This series of experiments, sponsored by Congress and the Department of Agriculture, ended inconclusively after only one season of testing. From Andrews County, the rainmakers moved to El Paso, which had been suffering from a severe water shortage. Once again, however, little rainfall resulted from their work, and criticism of the program increased. Nevertheless, Robert J. Kleberg<sup>qv</sup> employed the same group of experimenters to break the drought at the [King Ranch](#) in South Texas. Although heavy rain occurred, few responsible scientists were willing to attribute it to the explosions. In late 1892, the rainmaking team moved to Camp Farwell, near San Antonio, and initiated a new series of experiments. After no rain resulted, Robert MacFarlane, a physicist at the University of Texas, declared both the experiment and the theory faulty. Between 1910 and 1914, [Charles W. Post](#) conducted additional experiments in Garza and Lynn counties on the [High Plains](#). He detonated dynamite at four-minute intervals over several hours at a time. After four years of experimentation, the results were inconclusive and the trials ceased. This failure was apparently the final blow to the "concussion theory" of weather modification.

For several decades subsequent to the Post experiment, no weather-modification projects in Texas were documented. In the mid-1940s, Vincent Schaefer, a scientist at General Electric Laboratories in New York, discovered that dry ice could produce ice crystals in certain clouds. It was already known that ice crystals enhance precipitation; the discovery by Schaefer provided another option for weather modification. Bernard Vonnegut subsequently found that silver iodide, a substance with a crystal structure similar to that of dry ice, could produce ice crystals equally well; his discovery paved the way for modern seeding attempts using both dry ice and silver iodide. Irving P. Krick pioneered operational rainmaking activities utilizing the "new science" when he signed contracts with the West Texas Utilities Company and the city of Dallas to produce rainfall and break a difficult drought. Krick used ground-based silver iodide generators to

introduce crystals into the atmosphere. These were to be transported to the clouds by natural updrafts and produce ice crystals that would then produce precipitation. Although the results were inconclusive, these projects represent the beginning of modern weather modification in Texas. Cloud seeding with silver iodide or dry ice works in two ways. First, the artificial nuclei stimulate tiny cloud particles to grow and subsequently coalesce into large particles that may be precipitated, and second, enhancement of the condensation or freezing process releases heat to accelerate further growth of the clouds. To ensure the optimum concentration of artificial ice crystals in clouds, aircraft are now used to place the seeding agent in the cloud at the appropriate time and place. Also, if credibility and accountability are to be maintained, all efforts to modify clouds, whether experimental or operational, must be carefully evaluated. However, since it is practically impossible to separate seeding effects from natural occurrences, evaluation is inaccurate, and one must rely on statistical methods that require the collection of large amounts of data.

The number of commercial weather-modification projects in Texas increased markedly in the 1950s and '60s, prompting the state to adopt a statute controlling cloud-seeding operations. The Texas Weather Modification Act of 1967 charged the [Texas Water Development Board](#) to license and permit weather modification in the state and to promote research and development in weather-modification technology. Later, the act was codified in the Texas Water Code. Presently, the [Texas Water Commission](#) oversees weather modification. A license is granted solely on the basis of the knowledge and ability of the applicant. Permits to operate may then be granted to a licensee based on the merits of a particular project. Since passage of the law regulating weather modification in Texas, numerous projects have been conducted. Programs designed to increase precipitation have been sponsored by the [Colorado River Municipal Water District](#) in Big Spring, the [Edwards Underground Water District](#) in San Antonio, the city of San Angelo, and the city of Corpus Christi. With one exception, these projects were not sustained long enough to allow proper evaluation. That exception is the Colorado River Municipal Water District Program. Several studies have indicated that the project has resulted in increased precipitation in the target area.

Another application of cloud seeding is the suppression of hail. Because hail damages crops, a number of farmers in Hale County organized in 1970 to sponsor a project designed to reduce the occurrence of hail by seeding clouds from aircraft. This was the beginning of the Plains Weather Improvement Association. Three years later, farmers in Lamb County launched a similar program. The two groups, which coordinated their operation to prevent duplication, located potential hail clouds with radar and guided seeding aircraft to

the storm before it reached hail stage. Silver iodide was released in the cloud in large amounts to nucleate the formation of countless ice crystals in order to consume the available water before large hailstones were formed. The intent was to produce so many ice particles that none could grow particularly large; all would melt before reaching the ground. Controversy accompanied the project from the beginning. In 1976 the operations ceased amid claims that the seeding not only reduced hail but also reduced rain, by causing the particles to become so small that they evaporated before reaching the ground. No hail suppression projects have been initiated in Texas since that time.

Subsequently, a concerted effort was made by the federal government in cooperation with various states, including Texas, to advance weather modification. Early in 1973 the Office of Atmosphere Resources Management (a division of the Bureau of Reclamation) initiated the HIPLEX (High Plains Cooperative Experimental) Program, the purpose of which was to institute a verified working technology to produce rain from cumulus clouds in the High Plains states. One area selected for experimentation was the High Plains of Texas. This was the first scientific endeavor in the state to explore the potential of cloud seeding for rainfall enhancement. The ambitious six-year program made notable contributions to understanding shower-producing cloud systems in West Texas. In 1983 the Southwest Cooperative Program was launched as a follow-up to the findings and recommendations of the HIPLEX Program. This project was designed to develop a scientifically sound and socially acceptable weather-modification technology for augmenting water supplies in Texas and Oklahoma. Results of the three-year program indicated that the potential for rainfall increases from seeding is substantial in West Texas. It is becoming more apparent, however, that the ultimate decisions about weather modification will be made by the general public rather than by the legislature or scientists. The public's assessment of the economic, ecological, sociological, and legal factors will all play a role in determining how this technology is applied. The credibility of weather modification has certainly been tarnished by overstatements of success as well as exaggerations of failure or detrimental side effects. Nevertheless, considerable scientific progress has been made. Given the economic demand for water, there is little doubt that attempts at modifying the Texas weather will continue. *See also* [DROUGHTS](#), [WATER LAW](#) and other articles beginning with [WATER](#), and [WEATHER](#).

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*Donald R. Haragan*

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