HAIL SUPPRESSION

IMPACTS & ISSUES

HAIL SUPPRESSION
IMPACTS AND ISSUES

STANLEY A. CHANGNON, Jr., RAY JAY DAVIS, BARBARA C. FARHAR,
J. EUGENE HAAS, J. LOREENA IVENS, MARTIN V. JONES, DONALD A. KLEIN,
DEAN MANN, GRIFFITH M. MORGAN, Jr., STEVEN T. SONKA,
EARL R. SWANSON, C. ROBERT TAYLOR, JON VAN BLOKLAND

Final Report
Technology Assessment of the Suppression of Hail

ERP75-09980
Office of Exploratory Research and Problem Assessment
Research Applied to National Needs Program
National Science Foundation

ILLINOIS STATE WATER SURVEY
URBANA, ILLINOIS
APRIL 1977

Preface

Background of TASH project

In early fall of 1974 the Research Applied to National Needs Program of the National Science Foundation issued an announcement soliciting bids on several research topics. One of these called for the performance of an extensive technology assessment of hail suppression in the United States.

This announcement triggered interest in four persons – each from a different discipline – but all with an interest and experience in weather modification and a base of having worked together on previous projects. The interdisciplinary character of a technology assessment required both a diversified research team and a compatible one.

Discussions were pursued among the four – *Stanley A. Changnon, Jr.*, Head of the Atmospherics Sciences Section of the Illinois State Water Survey, *Professor Ray Jay Davis*, a lawyer at the University of Arizona, *Dr. J. Eugene Haas*, a sociologist at the University of Colorado and President of Human Ecology Research Services, Incorporated, and *Dr. Earl R. Swanson*, Professor of Agricultural Economics at the University of Illinois. The discussions led to preparation of a proposal that involved these four persons and their professional groups, plus *Dr. Martin V. Jones*, a technology assessment specialist of the Impact Assessment Institute.

The proposal was prepared under the auspices of the University of Illinois as the grantee institution and was submitted to the National Science Foundation in November 1974. The two co-located Illinois scientists -- *Changnon and Swanson* – were established as the co-principal investigators of the grant, with the grant to be administered and handled at the University of Illinois, Urbana Campus. The other team members were connected to the project through subcontracts or consulting agreements.

After further negotiations with NSF during the spring of 1975, the project was funded in mid-August 1975 and work began immediately. This grant for a Technology Assessment of the Suppression of Hail (TASH) was from the Office

of Exploratory Research and Problem Assessment of RANN, grant number ERP 75-09980 under the direction of *Dr. Pat Johnson,* Program Manager. Portions of the funding came from the Weather Modification Program of NSF/RANN, under the direction of *Currie Downie.*

An interesting and essential aspect of the project was the requirement for widely divergent expertise among the team. Gathering of the divergent expertise required involvement of team members and consultants from institutions widely scattered through the United States including Arizona, California, Colorado, Connecticut, Illinois, Oklahoma, Washington, D. C. and others. This dispersion in space and in interests necessitated a strong interactive research plan involving frequent use of conference calls and long-duration team meetings. Major project meetings occurred as follows:

Urbana, Illinois	August 1975
Boulder, Colorado	November 1975
Urbana, Illinois	January 1976
Tucson, Arizona	April 1976
Boulder, Colorado	June 1976
San Diego, California	September 1976
Chicago, Illinois	December 1976

In addition, there have been numerous team meetings at various scientific conferences where two or more TASH team members were present to give papers. Needless to say, there has also been extensive letter and memorandum preparation in an effort to keep everyone interested and involved at all times. When we consider the areal spread and intrinsic discipline-related differences of those involved (physical scientists, social scientists, business executives, weather modifiers, lawyers), the high degree of cooperation and attention to scheduling has been amazing. The basic responsibilities of the five groups involved in TASH were as follows:

The five TASH teams

- *Illinois State Water Survey* (ISWS) – project administration, meteorology and climatology, and impacted industries
- *University of Illinois* – all economic aspects
- *Human Ecology Research Services* (HERS) – all social and institutional studies
- *Ray Jay Davis* – all legal issues
- *Impact Assessment Institute* (IAI) – project guidance, environmental concerns, and special investigations

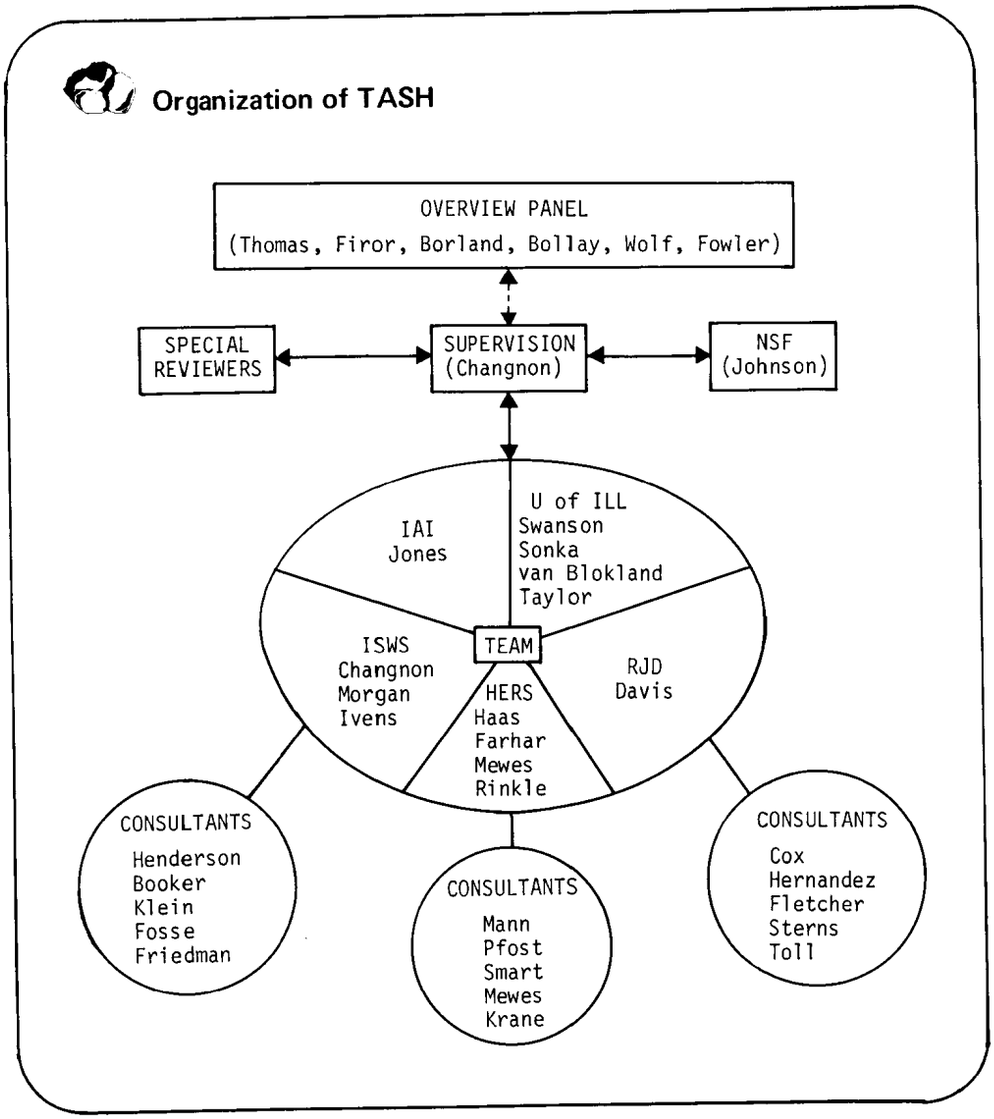
All but IAI were also scheduled to be heavily involved in the final project activity – transferring the results to users. The user interaction effort has involved not only the preparation of this final report, but also two user workshops and a summary publication, *Hail Suppression and Society,* to provide the most prominent TASH findings for general readers and policy planners.

Total funding for the 18-month project included $290,500 from NSF/RANN

and $60,000 from the State of Illinois. The project funds were allocated such that the Illinois State Water Survey received about $140,000, University of Illinois $70,000, Human Ecology Research Services $93,000, Ray J. Davis $25,000, and IAI $23,500.

Overview panel

The organization of TASH (*T*echnology *A*ssessment of the *S*uppression of *H*ail) is shown in the diagram below. Project supervision, largely in a management-organizational sense, was provided by *Stanley A. Changnon, Jr.*, of the Illinois State Water Survey. The project overview panel consisted of *William A. Thomas* of the American Bar Foundation, *Dr. John W. Firor* of the National Center for Atmospheric Research, *Dr. Stewart W. Borland* of Agriculture Canada, *Wayne L. Fowler* of DeKalb AgResearch Incorporated, *Dr. Charles P. Wolf* of the Office of Technology Assessment, and *Dr. Eugene Bollay*, a meteorologist and ex-owner of a weather modification company. These panelists



reviewed and guided the early planning of TASH, and have subsequently reviewed and commented on the third and fourth versions of the final report. Their interests and contributions have been invaluable to the project.

The major TASH team was composed of the five entities shown in the center of the diagram.

U of I team

The University of Illinois portion of the team included four agricultural economists under the leadership of *Dr. Swanson,* who directed the endeavors. *Dr. Steven T. Sonka* conducted the individual farmer analyses and the study of the value of future experimentation. *Dr. Jon van Blokland* modified the national economic model and analyzed the results therefrom, and *Dr. C. Robert Taylor* collaborated in the design and construction of the national economic model. Three graduate students assisted, including *Craig W. Potter,* who worked on the individual farm analyses, and *Emmett W. Elam* and *Klaus K. Frohberg,* who worked in the computer modeling and analysis of the national economic model. The research effort of *Dr. van Blokland* also became his doctoral dissertation and that of *Mr. Potter* was his masters thesis.

Authors identified by section

It should be noted that the authors of the various sections and subsections of this report are identified throughout according to the sections they contributed. Obviously, the economists contributed to information on the costs due to hail, and all other farm, regional, and national aspects of hail loss and its modification including benefit-cost studies. All team members participated in the review of all sections.

Impact Assessment Institute

The activities of the Impact Assessment Institute were under the direction of *Dr. Martin V. Jones,* an economist and specialist in technology assessment. He gave guidance in the methodology of technology assessment to the team, reviewed the products and commented on them, and helped in writing certain portions of the text. He was invaluable in guiding the team into technology assessment. He was assisted in a research and supporting role by *Richard M. Jones.*

Davis team

Professor Ray Jay Davis, of the College of Law at the University of Arizona, provided the legal analyses, interpretation, and related text. Much background research in various areas of law was required, and series of working papers were prepared by graduate students including *Steve Cox, Steven Hernandez, Guy Fletcher, Patricia Sterns,* and *Jim Toll.*

The activities of the consultants for the other major teams of TASH were comparable to those for Davis. *A basic approach used in TASH was to obtain background or "position papers" written by consultants. These were in turn used in building the final text.*

HERS group

The Human Ecology Research Services group was under the general direction of *Dr. J. Eugene Haas,* sociologist at the University of Colorado. *Dr. Haas* took on

the responsibility of integrating the results of the various components of TASH and thus the analysis of the impacts, the public policy options, and the recommendations. *Dr. Barbara C. Farbar,* also at the University of Colorado and HERS, coordinated the HERS work on TASH, prepared historical and case study material, the adoption analysis, and was a leader of the user workshops. *Julia Mewes,* Research Associate, prepared historical and case study materials, and *Ronald Rinkle,* also a Research Associate, prepared major data documents on societal parameters. *Sigmund Krane* contributed to the early development of the project, and *Charlotte Purvis* and *Dee Nervig* assisted with manuscript preparation.

HERS consultants

Dr. Dean Mann, professor at the University of California at Santa Barbara, was a major consultant to HERS and the entire TASH team. He brought expertise in political institutions and institutional arrangements and wrote several valuable position papers. Other consultants for HERS were *Dr. Horst Mewes,* consultant in political science, *Dr. Donald Pfost,* consultant in sociology, who conducted the study in nonadopting eastern tobacco areas, and *Dr. George Smart,* who was a consultant in sociology and prepared the case history on North Dakota.

ISWS team efforts

The Illinois State Water Survey effort was threefold. *Changnon* gave scientific guidance to the meteorological-climatological efforts of the Survey as well as providing project direction and working heavily on user interactions. *J. Loreena Ivens* prepared the sections on insurance, designed the format of the final report, and made a major contribution in the difficult and tedious task of reviewing, editing, and writing so as to give the contributions of 13 authors a flavor of single authorship. *Griffith M. Morgan, Jr.,* as a meteorologist performed the major analyses of hailstorm days and wrote portions of the text relating to the theories and techniques of weather modification. *Suzi L. O'Connor* did the type composition and makeup of the text and illustrations, *John W. Brother, Jr.* prepared the art work, and *William Schmidt* and *Patti Welch* worked in the editing and reference area. Other contributing Survey staff members included *Thomas J. Ealy,* who handled much of the complicated project business affairs and assisted in the management. *Kim Young* and *Mary Owens* did the extensive data and map plotting and proofreading of the report.

ISWS consultants

Consultants to the Water Survey were centered in three areas. First, to give guidance in the industrial sector of weather modification, *Thomas J. Henderson,* President of Atmospherics Incorporated, and *Dr. Ray Booker,* President of Aerometric Environment, served by reviewing documents and attending certain team meetings. *Dr. Donald A. Klein* of Colorado State University became involved through the preparation of the section on environmental impacts and was extremely helpful in this difficult area.

Major thanks go to *E. Ray Fosse,* Executive Secretary of the Crop-Hail Insurance Actuarial Association, for his considerable advice, attendence at team meetings,

preparation of an extremely valuable working paper on the crop-hail insurance industry, and provision at no cost to the project of extensive amounts of crop-hail loss data used by the University of Illinois economists. *Dr. Donald Friedman,* of Travelers Incorporated, also made a major new contribution by working in the area of property hail insurance, deriving the first good estimates of the amount of property loss from hail throughout the United States.

We would be remiss by not mentioning that the entire Water Survey TASH effort was done under the general direction of Dr. William C. Ackermann, *Chief of the Illinois State Water Survey. Without his enthusiastic backing and willingness to invest state funds in this project, it could not have been brought to a successful conclusion.*

Special reviewers

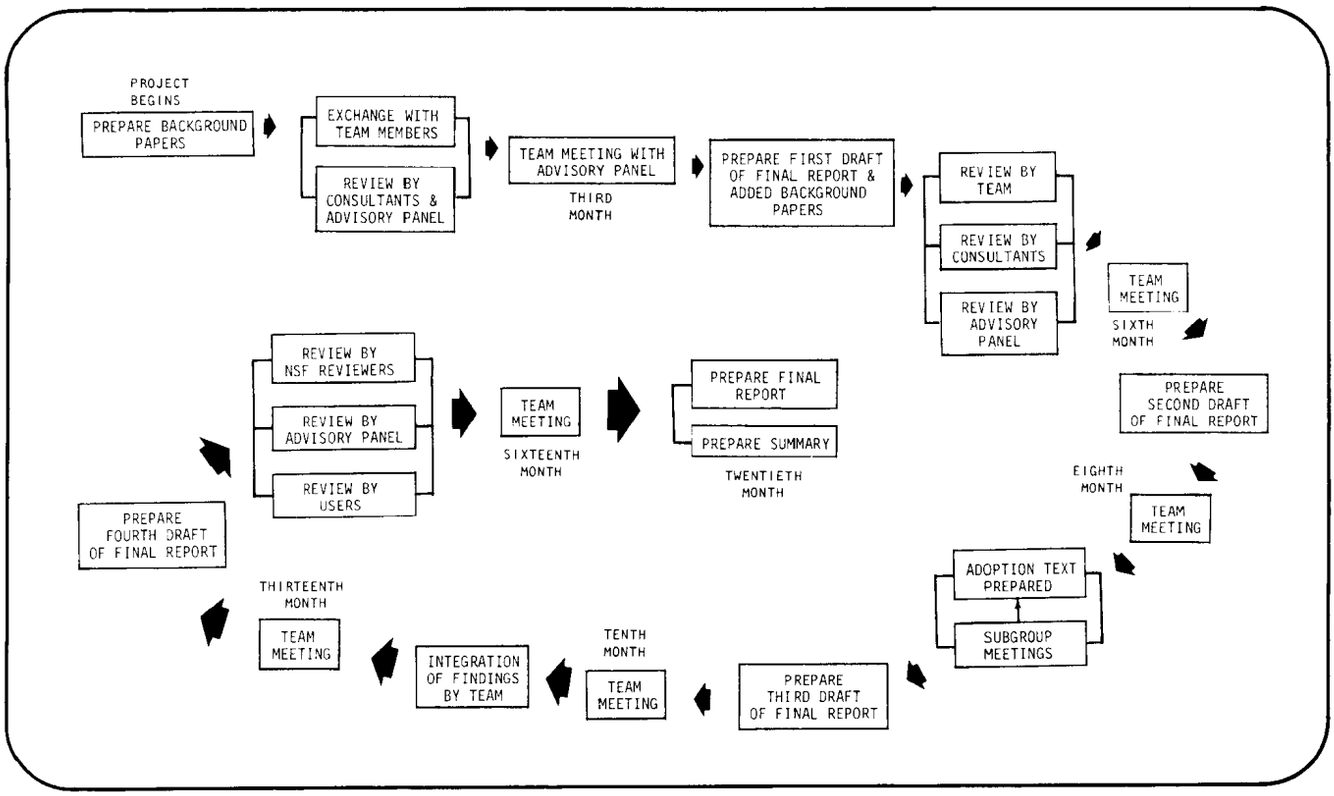
An early preparation of the final report was a major management strategy that guided the team's total efforts on this project. The full report was rewritten three times before the final draft was completed and submitted for sponsor review. This strategy, strongly urged by *Dr. Jones,* initially seemed infeasible to other team members. However, subsequent experience showed it to have at least two major advantages. First, it revealed important missing elements in the initial research plan and created a better appreciation for the project's dimensions and scope. Second, by having draft chapters available early in the life of the project, there was adequate time to obtain, and respond to, expert outside reviews. A box in the project organization chart *(page iii)* identifies this Special Review function, and the next paragraph lists the names of these reviewers.

Among those who have given reviews of portions of these TASH texts are *Philip S. Brown,* President of the Hail Information Service, who critically reviewed the sections on the insurance industry. *Bryce A. Sides,* Director of Corporate Communications, and *Louis Rediger,* Head of Hail Insurance, both of the Country Companies, reviewed and commented on these insurance sections also. Material on the present and future status of hail suppression and the related technologies were reviewed and commented on by *Professor Louis J. Battan* of the University of Arizona and *Professor Roscoe Braham* of the University of Chicago. *Dr. Charles P. Cooper* of San Diego State College and *Dr. Harold Steinhoff* of Colorado State University both graciously reviewed and commented on the environmental text. Others were asked to give reviews of the entire text of the third version of the final report, including *Dorothy M. Wetzel,* an Editor at the University of Illinois, *Marc Changnon,* a County Extension Specialist in Illinois, and *Professor Howard Taubenfeld,* Professor of Law at Southern Methodist University. Advice from *Dr. Larry Davis,* President of Colorado International Corporation, on seeding technologies was very helpful. All of these reviewers gave their comments and their time at no expense to the TASH project and in all possible instances their thoughtful comments were incorporated to both correct and improve the TASH material. The critical reviews of the 34

persons who attended the TASH workshops to help us develop the summary document were extremely useful in revising and improving this final report. Our deepest gratitude goes to these people and to our special reviewers.

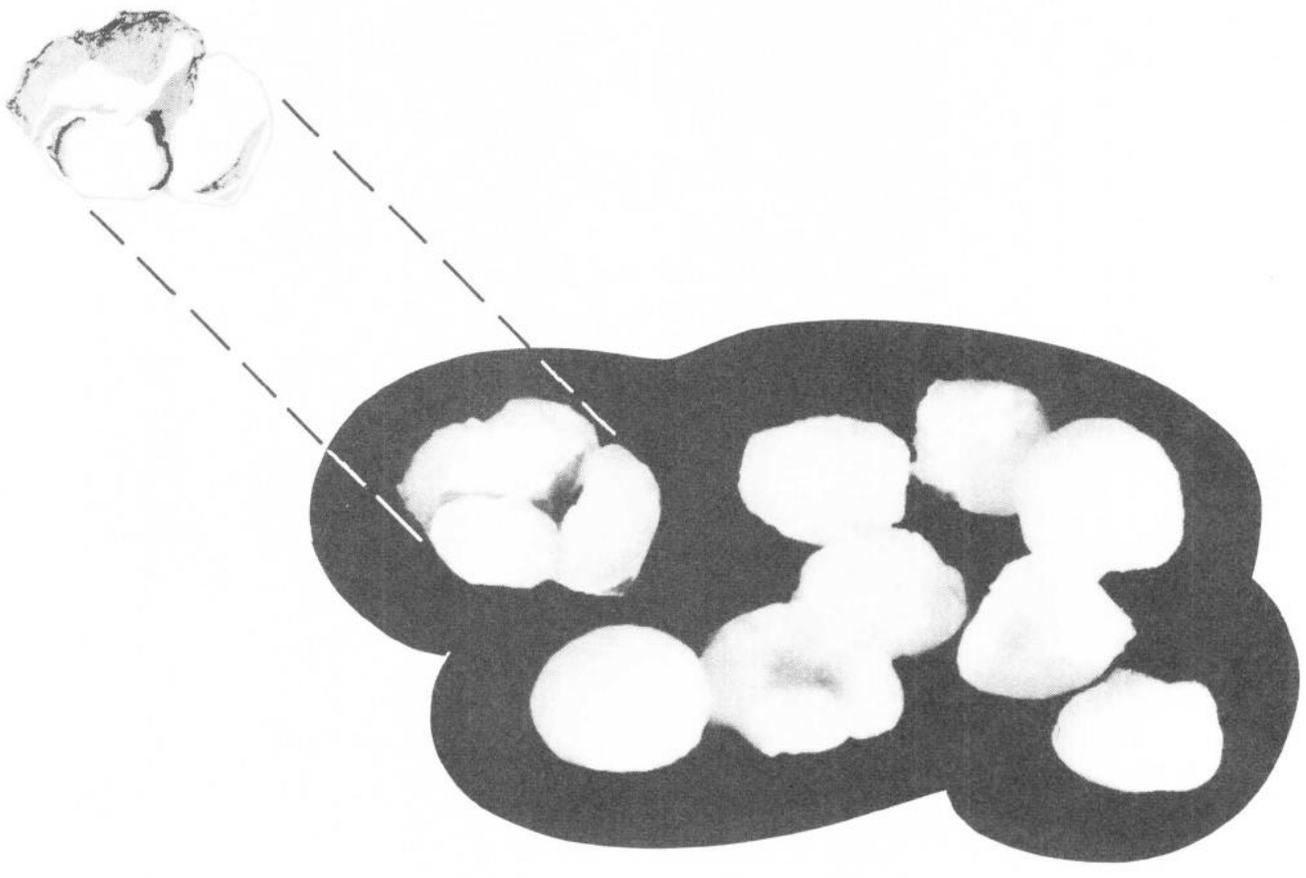
Two workshops were conducted in November 1976 to inform representatives from all groups interested in hail and its suppression about TASH results. Representatives came from diverse geographical areas and included people from state and federal government agencies, farmers and farm groups, the insurance industry, the weather modification industry, weather research groups, agribusiness, and environmental concerns. During these workshops, the participants provided their views as to key findings to guide us in the preparation of a separate summary document for TASH, *Hail Suppression and Society.* This short publication will be widely available.

A major issue in successful multidisciplinary research involving scientists with widely diverse backgrounds is the development of working interactions. This interaction was particularly critical for TASH since team members were distributed across the nation (Washington, D.C., Illinois, Colorado, Arizona, and California). The sequence of events involving the writing of informational (background) papers from each discipline, the writing and revision of five versions of the final report, the internal and external reviews of these documents, and team meetings is illustrated below, showing the truly multidisciplinary effort reflected in this report.



Part 1

The problem and solutions



Cover photograph of an approaching July
hailstorm in South Dakota, taken
by Stanley A. Changnon, Jr.

This report was prepared with the support of National Science Foundation Grant No. ERP 75-09980. The opinions, findings, conclusions and recommendations expressed in such a publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Contents

Part 2. The past and present