EVALUATION OF OPERATIONAL WEATHER MODIFICATION PROJECTS*

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> "It is hard for an empty sack to stand upright"
>
> B. Franklin
> Poor Richard's Almanac, 1758

I. INTRODUCTION

Benjamin Franklin (1706-1790) of Philadelphia, Pennsylvania, has often been lauded as a printer, author, publisher, inventory, public servant, diplomat, philospher, and scientist. His scientific work and writings covered many fields including health, medicine, music, chemistry, agriculture, geology, physics, and meteorology. He can be properly viewed as one of the first American atmospheric scientists for his investigations including lightning, waterspouts and whirlwinds, storm propogation, and cloud electrification (Goodman, 1931).

Franklin apparently was a curious, ingenious, parsimonious, and practical person who, when an explanation of some phenomenon was not forthcoming or satisfactory, usually investigated it himself. His investigations, both laboratory and field, typically had the hallmarks of logical and rational procedures, unique and simple equipment, careful collection of data, patient checking of results, and the drawing of far-reaching consequences. In short, Ben generally conducted well designed and evaluated investigations whose precepts are worth following in any year.

In the spirit of Franklin, this article will offer some views on how one might best undertake a "solid" investigation of the "effects" of an operational weather modification project. An operational weather modification project is defined here as a project whose principal goal is to produce an *a priori* agreed on modification, such as an increase of snowpack of a designated watershed. In contrast, a research project or experiment would have as its principal goal the discovering and understanding of how snowpack can be modified (either increased or decreased). Although this article is focused on the former, much of the discussion also will be relevant to the latter.

The proper evaluation of any project, irrespective of the subject, begins with its design and extends through the implementation of the design (including the data collection, data reduction, data management, analyses,

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and interpretation) to the reporting of the results. Thus, proper evaluation is: (1) purposive and planned, not after the fact or act; (2) virtually inseparable from the project itself (permeats all stages); (3) the guiding mechanism for seeing the project through; and (4) the only foundation for meaningful interpretation of the results of the project.

With regard to operational weather modification projects, proper evaluation fulfills the following functions: (1) it places the project's results on a scientific rather than a "personal faith" or anecdotal basis (the succinct New Yorkercartoon which shows two clergymen gazing through a church window at some falling raindrops and asking, "Is it ours or theirs" well exemplifies the point); (2) it allows the weather modifier to monitor his "product or service" in order to assure that the prespecified product is being delivered (i.e., it attempts to assure that the proper modification opportunities are being utilized and are producing the promised results); (3) it hopefully provides an opportunity to learn more about the process in order to improve the "product or results"; and finally, (4) it serves as the main rationalization for continuing client support of the project and initiation of new projects. J. Simpson (1975) and others have remarked that rarely, if ever, does an operational project continue to receive support for more than three to five years unless a substantial evaluation is part-and parcel of the project. The history of operational weather modification projects and operators seems to well support this statement.

II. BRIEF HISTORY OF EVALUATION

The early evaluation procedures for operational weather modification projects appear to have been borrowed directly from the pioneering work of Schaefer (1946) Langmuir (1948), and Vonnegut (1947). These three researchers conducted a number of carefully controlled laboratory experiments on nucleation in 1945-1946, and a number of the results could be visually demonstrated. In fact, the first field seeding trials by Schaefer and Langmuir, in the fall of 1946, apparently were on lower level stratus cloud formations and were evaluated by visual observation. McDonald (1969) has termed this evaluation approach the "seed-and-look" method, for one simply seeds and then literally looks for evidence of subsequent precipitation.

Although the visual or seed-and-look evaluation approach may have been relevant in well-designed and controlled experiments in the laboratory, the natural variability of the atmosphere (coupled with the lack of an ability to predict or control it) quickly questions its general use in field trials. Thus, by 1950, evaluations of operational projects were beginning to rely on comparisons of the observed target area precipitation with the corresponding historical long-term "normal" precipitation. Let the observed precipitation at gage j in the target area (T) for a month of seeding be denoted by $Y_{S,j}$ and the corresponding "normal" precipitation (based on some historical period) for the same gage be denoted by $Y^{*}_{NS,j}$, then the ratio

$$R_T = \left(\sum_{j=1}^{k} Y_{S,j} / \sum_{j=1}^{k} Y^{*}_{NS,j}\right) \times 100 \qquad (1)$$

is often termed the percent of monthly normal precipitation for the designated target area (T). Note that the denominator of R_T presents a prediction of the precipitation that would have occurred in T if there had been no treatment (seeding). Hence, the ratio R_T compares mean observed with mean predicted precipitation in an attempt at estimating the treatment effect.

This percent-normal method of evaluation was modified in about 1951 to allow the use of precipitation from a control area. Letting $X_{S,i}$ and $X^*_{NS,i}$ denote the observed and "normal" monthly precipitation amounts for the i^{th} gage in the control area, the corresponding ratio for the control area is

$$R_C = \left(\sum_{i=1}^{h} X_{S,i} / \sum_{i=1}^{h} X^*_{NS,i} \right) \times 100. \tag{2}$$

Then, the ratio R_T/R_C also is an estimator of the treatment effect and it allows auxiliary information (precipitation in the control) to aid in predicting what the target area precipitation would be in lieu of treatment (MacCready, Jr., 1952).

A third generation of evaluation methods began to appear in about 1952, the target-control regression method (Brier and Enger, 1952; MacCready, 1952). This approach regressed the target area precipitation (possibly transformed) upon the control area precipitation for some historical period in order to calculate the regression coefficients A and B. The resulting regression equation, $Y^* = A + BX$ (where Y^* is the predicted precipitation in the target area based on the corresponding precipitation X in the control area), is then applied to the seeded period in order to calculate the difference between the observed and predicted precipitation in the target area for the t^{th} time unit, $d_t = y_t - y^*_t$. These differences or departures, d_t, are then subjected to various statistical analyses in order to search for evidence of a seeding effect.

For the target-control regression method (and the percent-normal also) to be an appropriate evaluation tool, one must be able to meaningfully assume that the natural precipitation process is stable over the relevant time and space. If this is not the case, then part or all of the calculated d_t's simply may be due to changes in the natural precipitation process and not due to treatment.

Brier and Enger (1952) were the first to provide evidence that the needed stable relationship between target and control may not always be present. They found that for a central Arizona operational project the size and the statistical support for the departures varied substantially with the length of the historical record and varied moderately with the particular selection of gages. Three years later, Vernon (1955) presented evidence that the target-control regression coefficients can change with type of storm. Needless to say, one can hypothesize a number of other factors that might affect the presumed stable target-control relationship and Neyman (1967) has mentioned a number of them. Interestingly enough, the NAS-NRC Panel

(1966) had some of these possible biasing factors (i.e., stopping rule, storm type, etc.) investigated, and the resulting view seemed to be that although these biasing factors can exist they may not be sizeable.

III COMPONENTS OF A COMPLETE EVALUATION

As indicated earlier, the design, implementation, and analysis of an operational weather modification project is both an opportunity and a responsibility. To properly and completely fulfill the evaluation responsibility, the following components must be given detailed attention: (1) objectives and scope of the project, (2) working models, (3) dimensions of interest and their measurement, (4) treatment design, (5) feasibility, (6) data management, (7) analysis of the data, and (8) reporting of the results. Let us briefly examine each of these eight components in order to understand some of the problems that must be faced and resolved in a proper and complete evaluation. A number of these components have been discussed from the research viewpoint in three important publications (NAS-NRC, 1959; Brier, 1974; Flueck and Mielke, 1976).

A. Objectives and Scope

The precise specification of the objectives and scope of a weather modification project is one of the most important, and sometimes one of the most neglected, components in the project's design. This step serves as a foundation for the project and the efforts invested here should provide returns thoroughout the other steps. In short, this step serves to focus the project on its "subject".

The project designers should insist on clear and concisely written statements from the sponsors as to the desired goals of the project. A legal contract may be utilized fully indicating the "product", the terms, the liabilities, etc. However one handles this step, the essential point is to achieve a well-defined and mutually agreed upon set of objectives.

The scope of the project also aids in establishing the focus, and sometimes it is useful to clearly establish what is not within the scope. Questions such as (1) Is the client only interested in argumentation in the primary (target) area; (2) Should the project also focus on an extended area; and (3) Are all storms to be considered within the scope of the project; should be useful in establishing the scope of the project. Needless to say, the questions and their answers, concerning the objectives and scope of the project, also should serve to initiate thinking about the possible working models of the atmospheric process of interest and the resulting feasibility of the project.

B. Working Models

Every weather modification project should have at least one "working" model that it attempts to follow in order to produce its desired modification effect. These models may simply be conceptual but should be strongly based on accepted physical and theoretical results. They are termed "working" to indicate that they are often incomplete descriptions of reality, and as consistent meaningful results from research experiments and operational projects continue to come forth, these working models should become more complete and accurate descriptions of the particular atmospheric process.

The selection of the particular working model or models is based largely on a number of preliminary studies that must be conducted in the location selected for the modification. A climatological description of the project area and a physical description of the cloud populations are two studies that must be performed. In addition, a micro-physical study of the clouds generally is needed in order to properly identify the treatment opportunities and discriminate between the alternative working models. As we will shortly see, some of these prelimimary studies will evolve into monitoring activities as the project progresses in order to assure the client, and the modifier, that the project is "on course".

The project designer also must begin to consider various treatment methodologies at this point. Clearly, the treatment method must be closely tied to one's model, or view, of how the modification can be achieved.

C. Dimensions of Interest and their Measurement

The "dimensions of interest" are simply the dimensions of the project that one desires to measure in order to monitor the project's performance and gain information about the particular atmospheric process. These dimensions are quantified by instrumentation and thus "define" variables that are hopefully "close cousins" to the original dimensions of interest.

Two types of variables will be briefly discussed: response variables, and auxiliary or "predictor" variables. Response variables are those dimensions or quanitities of a project that one observes in anticipation of finding a response to the "treatment". The best response variable is not always obvious as Changnon (1969) has indicated in the case of hail. Also, more than one response variable is often utilized, particularly when there is considerable uncertainty as to the form of the possible treatment effect. However, a "sharper" project is generally produced if one or two response variables are used as the central focus and the others are viewed as secondary.

The auxiliary or predictor variables (Brier, 1974) are measured because they are considered related to, and instrumental in, producing and assessing the treatment effects. Some of these variables are used for pre-screening of the treatment opportunities (i.e., temperature, vertical velocity, water vapor content, etc.), while others, including some of the same variables, are used for post-screening in order to learn more about the treatment effect. In either case, the preferred approach is to measure not only those predictor variables that are directly a part of the implicit or explicit working models but also a few that presently are considered less important. It is not entirely unusual for some members of this later group to eventually prove to be of primary importance in the production and assessment of the treatment effect (e.g., Flueck, 1971; Mielke et al., 1971).

Instrumentation, or the quantification and collection of the values of the response and predictor variables, is a sizable topic in itself. Suffice it to say here that some combination of ground-based aircraft and remote probing instrumentation will typically be required for a weather modification project. However, the emphasis should be on reliable proven instrumentation with automatic self-recording capability. The time and space resolution will depend on the budget and the particular situation.

D. Treatment Design

This component of the evaluation is directed at designating what is to be treated, where, when, how, how much, and how often. More formally the questions are: (1) what is the treatment unit; (2) Where will the treatment be applied; (3) When and how will it be applied; (4) How much will be applied; and (5) How often will it need to be applied in order to detect its effect.

The selection of the potential treatment unit usually follows from the objectives and working models and often is the day or some subset of it. The benefits of using the day are somewhat obvious: it (1) meaningfully handles the diurnal cycle, (2) allows for both day and nighttime treatment, (3) provides a natural "clearing period" between treatment units, (4) typically provides for considerable replication of the treatment, and (5) produces a convenient operational time unit.

A question related to the treatment unit is whether "prescreening" should be used. Prescreening simply means that only certain designated days (units) will be declared as operational days, and most projects appear to use it. Days in which the equipment is not useable and days which the client prespecifies as "no treatment" days are examples of prescreening.

Closely related to the treatment unit is the observational unit. One is often interested in gaining a finer resolution of the effects than that provided by the treatment unit, and the observational unit is the device used to secure this finer resolution. It allows one to collect information on a subset of the treatment unit and hopefully attain a better picture of the process. The observational unit has produced some of the strongest evidence of an effect in a number of weather modification research experiments (NRC, 1973).

The question of where will the treatment be applied and where will it be evidenced brings us back to the working model(s) of the atmospheric process of interest and to consideration of the physical configuration of the project's target and control areas. The NRC Report (1973), Brier (1974), and Flueck and Mielke (1976) present a number of alternative configurations (target only, target-control, etc.) and the general view seems to be that a target-control type design is preferred provided that the absolute value of the correlation between the target and control is greater than .30 and the possibility of contamination in the control is low. I will return to this correlation point later.

The questions of when and how will the treatment be applied and how much should be applied returns one to the previously mentioned working models, the preliminary studies, and the treatment (seeding) methodology. Two additional points are worthy of note here. First, serious consideration should be given to the use of randomization in the selection of treatment units in an operational project. The "treatment-to-no-treatment" proportion does not have to be fifty-fifty and it can change over the duration of the project and not compromise the evaluation. This monitoring of the treatment process will be more complete, and natural atmospheric changes will not be mistaken for treatment effects. Second, in many disciplines (medicine, biology, chemical engineering, etc.) when the optimal amount of treatment (dosage level) is not known, controlled experimentation is encouraged in order to search for the optimal level (Davies, 1956). Weather modification projects would do well to try these practices. A common technique involves systematic searching on both sides of the initial selected dosage level.

Lastly, the question of how often should the treatment be applied in order to clearly detect the treatment effect involves the problem of the sample size, "n", needed for such detection. As indicated earlier, the detection or monitoring of the treatment effect is just as important in a weather modification project as it is in a research experiment. The standard research approach to estimating the needed "n" is via hypothesis testing employing the probabilities of type I (α) and type II (β) errors (Cochran and Cox, 1957). I believe this approach to be fundamentally incorrect (i.e., we usually are not interested in "sharp" null and alternative hypotheses, etc.), and it typically gives over-inflated estimates of "n".

The appropriate approach to estimating "n" is from the estimation viewpoint, i.e., the confidence interval (Cochran, 1963), and allowing for predictor variables it gives the following equation:

$$n = \frac{z^2_{1-\alpha}(\sigma^2_S + \sigma^2_{NS})}{[(\mu_S - \mu_{NS}) - (\bar{X}_S - \bar{X}_{NS})]^2} \cdot (1 - R^2) \qquad (3)$$

where:

$n = n_S = n_{NS}$ = the number of seeded or not seeded treatment units;

$z_{1-\alpha}$ = the standardized normal value for the $1-\alpha$ level of confidence

σ^2_S or σ^2_{NS} = the population variance for the S or NS units;

μ_S or μ_{NS} = the population mean for the S or NS units;

$\bar{X}_S$ or $\bar{X}_{NS}$ = the sample mean for the S or NS sample units;

R^2 = the coefficient of determination from a linear regression of the response variable on the predictor variables.

The denominator of equation(3)represents a pre-specified maximum squared difference that can occur between the population and sample means $1-\alpha$ of the time. The term $(1 - R^2)$ is appended to the equation in order to allow predictor variables to explain some of the natural variability (reduce the noise level) and allow for quicker detection of the treatment effect. Equation (3) can be written as $n = K(1 - R^2)$, and thus one can quickly determine the reduction in sample size achieved by utilizing predictor variables. Figure 1 presents the graph of equation (3) for a given K. The importance of "good" predictor variables is dramatically illustrated. If the multiple R (the square root of the coefficient of determination) is .70, the sample size may be reduced by one-half.

E. Feasibility

This component in the design of a weather modification project is crucial for it serves as an early evaluatory step of the project. In short, the feasibility question is, "Can one meaningfully perform the service and produce the desired results within the designated time and dollar budget?" The benefit-cost calculations are all pervasive. They should include not only the standard costs and possible benefits for various degrees of "success," but they should also consider the legal and environmental impacts.

Needless to say, the feasibility study must be continuing one throughout the design stage of the project. Even upon commencement of the project, the feasibility issue will be present in at least one form. The project managers, sponsors, outside advisors and reviewers, and the "special interest groups" will "monitor" the operations and the performance of the project. Feasability of a project is always with us in one form or another, whether we like it or not.

F. Data Management

I will define data management rather broadly and include the following four topics in it: (1) data collection, (2) data reduction, (3) database construction or design, and (4) database management. Unfortunately these topics often are given little attention in the design of a weather modification project. This is hopefully changing on two counts. First, data management has become an important topic in its own right in computer and information science (Date, 1975; Martin, 1976). Second, more weather modifiers are realizing the important benefits that can accrue from careful work on this step.

Data collection or acquisition is used here to cover the activities of physically acquiring the values for the selected response and auxiliary variables. It clearly interfaces with instrumentation and includes the ground level, aircraft, and remote sensing observational systems. The perfect data collection system would correctly record all response and auxiliary events of interest, store this information in machine (computer) readable form, and provide a well organized error-free "readout" of the collected data. One should start with this design goal for the data collection system and only retreat reluctantly.

The data reduction or processing system should include some quality control procedures. Every instrument's daily output should be regularly sampled by the relevant staff member and the entire collection process should be designed so that a day's data can be processed to disk storage and a computerized initial edit can be quickly performed. As Flueck and Mielke (1976) indicate, the data reduction model to emulate is that of a competent public opinion survey organization with its field edits, branch office edits, and central office editing, coding, and assembling of the data tape. Note that not all of the collected data need be reduced if upon inspection some data items seem less useful than others.

Database design is primarily concerned with the indexing and organization of the data in order that it can be easily and efficiently utilized to provide needed information (Date, 1975). The traditional sequential file with the records (a day's values), fields (variables of interest), and characters (individual symbols) is probably suitable for many operational projects. However one designs the project's database, careful planning and thought should be directed to this task before any data is collected and processed. A review of the database design with an expert may be a useful precaution.

Database management refers to the ability to easily and orderly retrieve, update, edit, reorganize, display and crudely summarize the database (Martin, 1976). The ability to easily work with and produce summary reports clearly improves the project's standing with its clients. Of course, not all weather modification projects can justify a completely computerized database management system, but the ability to quickly and easily generate "current status" reports of a number of different types should not be overlooked.

Lastly, one should not underestimate the time and effort needed to appropriately perform the data management functions. This step will provide the permanent "capital" upon which the subsequent analyses will draw. Any losses here will be largely unrecoverable later.

G. Analysis

An increasing number of weather modification researchers (e.g., Flueck 1971), Brier (1974), and Flueck and Mielke (1976) are advocating and using a "data analysis" approach to analyzing data. This "data analysis" viewpoint is not a new one (J. Kepler (1571-1630), J. Graunt (1620-1679), and B. Franklin (1706-1790) practiced this approach), but it is receiving fresh and growing attention in this present period. Tukey (1962, 1970-1971), Tukey and Wilk (1965), Mosteller and Tukey (1968), and others have been renovating and refining its theory and methodology.

Data analysis (applied statistics as some term it) is best viewed as a science which is dedicated to the extraction of the relevant informational content of a database through the employing of flexible iterative techniques directed at exposing, discovering, summarizing, and confirming (all in an interactive manner) the structure and relationships of a process. Data analysis usually distinguishes between exploratory and confirmatory procedures, and I will maintain this dichotomy.

Data analysis is like an "archeological dig" in that both attempt to uncover, explore, recreate, report, and confirm the structure and relationships present in the "data". In both cases careful, detailed, interactive, and fully reported efforts are utilized. One might even claim that data analysis is the doing of science.

The principal idea of exploratory data analysis (discovering patterns and relationships) has been well stated by Tukey and Wilk (1965) as, "The iterative and interactive interplay of summarizing by fit and exposing by residuals is vital to effective data analysis. Summarizing and exposing are complementary and pervasive". As such, the statisticians hypothetically views his data as,

$$\text{observation} = \begin{pmatrix}\text{incomplete}\\ \text{description}\end{pmatrix} + \left(\text{residual}\right) \quad ,$$

and the entire task is to keep moving the information from the residuals to incomplete description. There generally is a definite hierarchy with the more evident relationships being uncovered first and the more embedded ones uncovered later. Note that I have used the phrase "incomplete description" in place of working model. This is to emphasize that all models are incomplete and only approximations to reality.

The methods used to figuratively move the information from the residuals to the incomplete description have been discussed and well illustrated by Tukey (1970-71), Flueck (1971), Brier (1974), Flueck and Mielke (1976), and others. It should be noted that visual display plays an important role in all areas of data analysis. These displays include stem-and-leaf plots, box-and-whisker plots, graphs, scatter plots, probability plots, frequency tables, etc.

Figure 2 presents an example of a visual display for the hail severity data from a South African hail suppression project (Mielke, 1975). The two back-to-back stem-and-leaf plots of the severity ratios for the storms seeded by propeller compared with those seeded by jet aircraft well illustrate the usefulness of visual displays. The propeller seeded values are more disperse, tend to have higher severity values, and have three outliers (.82, .90, and .98). The corresponding five number summaries (M = median, Q_0 = minimum, Q_1 = 1st quartile, M = median, Q_3 = 3rd quartile, and Q_4 = maximum) at the bottom of figure 2, well support this picture.

Thus, the indications of the data display are that the jet aircraft seeded storms produced: (1) less severe hail than the propeller aircraft seeded storms, (2) less variable hail severity, and (3) no extremely large severe hail storms. Mielke (1975) arrives at essentially these same views based on a number of statistical tests. Note that effective data analysis never depends solely on a single "magic" summary number. This is wrong in principle and in practice.

Confirmatory data analysis (assessing the support for the discovered relationships) has received less current attention than exploratory data analysis and thus its methods are more open to discussion. From the viewpoint that data analysis is a science, Flueck and Mielke (1976) have suggested confirmatory data analysis should judge the strength of a result (indication)that by: (1) the relative size of the result with respect to the natural variability, (2) the consistency of the result over time and conditions, (3) the meaningfulness of the result with respect to other accepted results, and (4) the important element of personal judgement.

Hence, indications are results that appear promising, but have yet to be "strongly supported" by the above criteria. Alternatively, conclusions are indications that already have been strongly supported by the criteria. It is interesting to note that the first element of this criteria is often used as the sole measure of confirmation by a number of researchers.

Given the above interpretation of confirmatory data analysis, an important characteristic of the data analysis view is that it can be utilized on both nonprobability based (nonrandomized) and probability based (randomized) data. Both are viewed as containing relevant information worthy of careful investigation. This characteristic does not imply that carelessly collected data can be used to produce well-founded results. Poorly collected (designed) data will only lead to poorly founded indications.

H. Reporting

The reporting step of evaluation often is one of the most important and one of the least planned. The entire project can be well designed, executed, and analyzed, but still the project can be lost in the reporting.

First and foremost, the confidence placed in the indications and conclusions produced by the project can be affected by the reporting procedure. Full and honest reporting will be required in order to properly satisfy the four elements of confirmatory data analysis. This means that all attempted analyses and results will have to be offered to the client.

Second, a summary of the database, by treatment unit, also will have to be offered to the client. One will have to be prepared to allow the client to check the claimed results using the same data.

Finally, it generally will be advantageous to plan to release a sequence of reports, some early and preliminary and others later and final. The interest of the client in the project must be maintained and he should be properly informed so that he can understand the full effects of all results.

IV. CONCLUDING REMARKS

Ben Franklin has well written that "many words won't fill a bushel" and hence these final comments will be kept brief.

The paper has attempted to present a complete and thorough design and evaluation system usable in any weather modification project. Considerable effort and resources will be needed if the full task is to be properly performed. It probably requires a team of talents.

I've tried to indicate why a proper and complete evaluation is required in all weather modification projects. The weather modification product is a highly "technical" one, and thus a more research oriented approach is needed in the evaluation.

Finally, if the presented evaluation prescription is followed, it is the author's strong belief that weather modification projects will become more publicly acceptable, creditable, and in the long-run more profitable to the industry. In short, evaluation must plan an important role in the future of operational weather modification projects or there may not be one.

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FIGURE 1

THE RELATIONSHIP BETWEEN n AND R

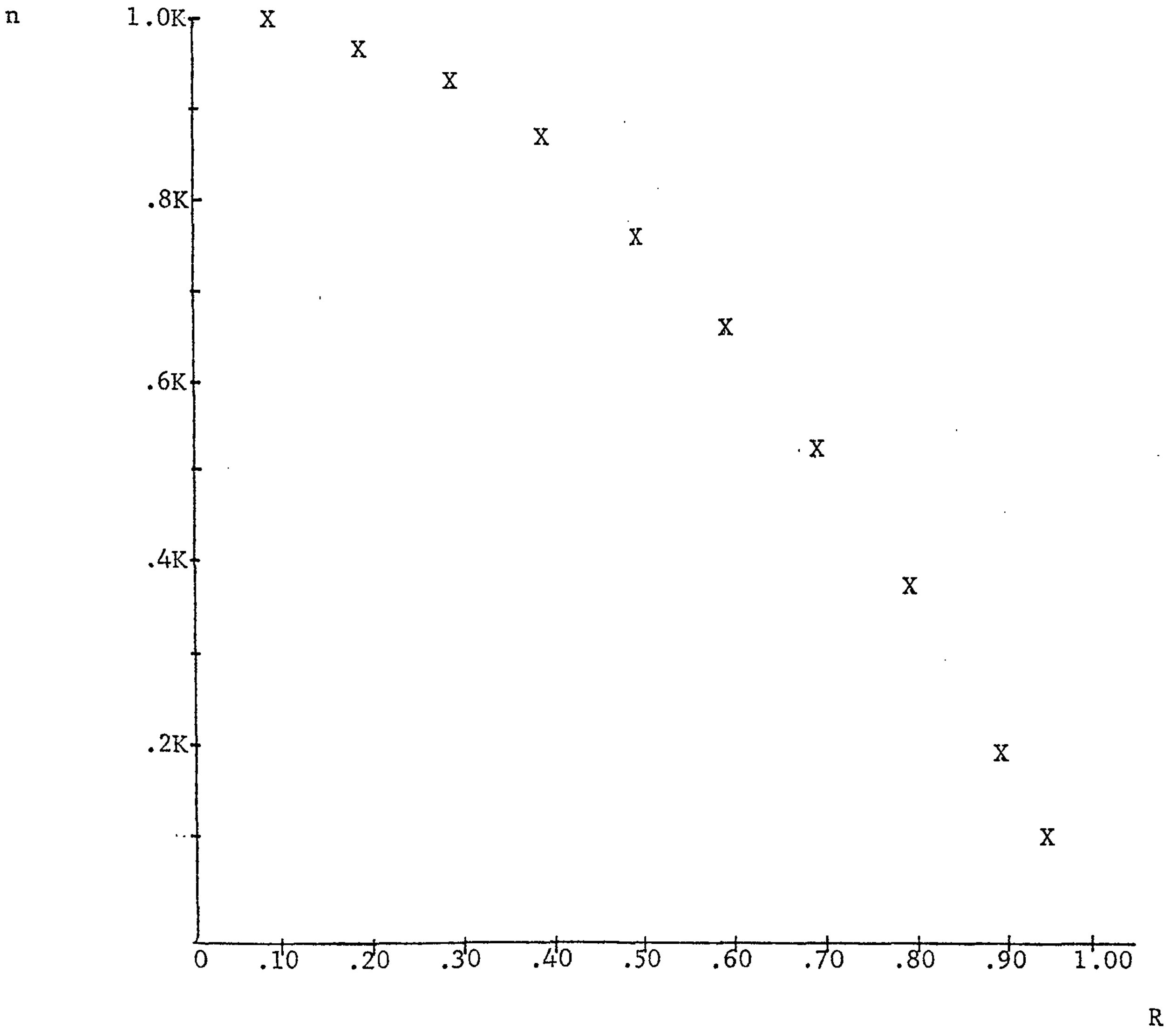

FIGURE 2

BACK-TO-BACK STEM-AND-LEAF PLOTS OF THE 1972-74 HAIL SEVERITY RATIO FOR PROPELLER AND JET AIRCRAFT SEEDED STORMS IN A SOUTH AFRICAN HAIL SUPPRESSION PROJECT

	Propeller		Jet	
		.00		
		.10		
(2)	6,2	.20		
(3)	7,7,3	.30	3,3,5,6,7,8	(6)
(9)	8,8,8,6,6,5,4,2,0	.40	2,3,6,7	(4)
(5)	9,8,7,4,3	.50	4,7,8	(3)
(5)	8,8,5,1,0	.60	1	(1)
		.70		
(1)	2	.80		
(2)	8,8	.90		
(27)				(14)

Five Number Summaries for the above data.

27		
M	.48	
$Q_{1,3}$	.43	.605
$Q_{0,4}$	.22	.98

14		
M	.425	
$Q_{1,3}$	.36	.54
$Q_{0,4}$	.33	.61