RELATIONSHIP OF CHARACTERISTICS OF THE RESEARCH METHODS USED IN TWO SUBFIELDS OF GEOLOGY AND THE GROWTH OF PUBLISHED RESEARCH IN THOSE SUBFIELDS

DISSERTATION

Presented to the Graduate Council of the North Texas State University in Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Mary Sue Stephenson, B.A., M.L.S.

Denton, Texas

December, 1982

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The major problem addressed by this study was to investigate the relationship between characteristics of the research methods used in selected subject subfields and the growth of published research in those subfields. In order to carry out the investigation a non-experimental design was employed, and an evaluative instrument was developed for assigning a quantitative score to published research based on characteristics of the research methods utilized. Evaluative scores were thus assigned to 244 randomly selected research studies drawn from two scientific subfields manifesting different rates of growth. The data thus obtained were analyzed to test the hypothesis that a correlation exists between the characteristics of the research methods used in a subject subfield and the growth of the published literature of that subfield. In testing this hypothesized relationship the field of geology was selected as the major discipline of interest, and the two subfields studied were geochemistry and vertebrate paleontology. A Kendall tau c coefficient

of .57182 ($p < 0.00001$) was obtained using ungrouped evaluation scores. Using grouped research methods evaluation scores, a Kendall tau b coefficient of .41838 ($p < 0.00001$) was obtained. In both cases the major hypothesis was supported. The hypothesized relationship also remained substantially unchanged when possible effects of selected control variables (relating to author characteristics) were considered.

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CHAPTER I

PURPOSE AND PROBLEM

The major problem addressed by this study was to investigate the relationship between characteristics of the research methods used in selected subject subfields and the growth of published research in those subfields. In order to carry out the investigation a non-experimental design was employed, and an evaluative instrument was developed for assigning a quantitative score to published research based on characteristics of the research methods utilized. Evaluative scores were thus assigned to 244 randomly selected research studies drawn from two scientific subfields manifesting different rates of growth. The data thus obtained were analyzed to test the hypothesis that a correlation exists between the characteristics of the research methods used in a subject subfield and the growth of the published literature of that subfield. In testing this hypothesized relationship the field of geology was selected as the major discipline of interest, and the two subfields studied were geochemistry and vertebrate paleontology. The background, significance, and principal aspects of the problem are considered in the following sections of this chapter.

Introduction

The acquisition of publications is obviously one of the librarian's basic functions. The acquisition process is complicated, however, by both the on-going explosion of information available for selection and the fluctuating resources of even the largest libraries. Since the planning aspects for acquisitions may be as significant as traditional philosophical considerations, there is a definite need for further research on these aspects.

Implicit to the concept of planning is the development and implementation of valid guidelines based on predictive models. In the past, unfortunately, many acquisition decisions were essentially ex post facto responses rather than carefully planned actions; collection managers would come to recognize only belatedly that particular areas of knowledge were expanding or contracting, and acquisition decision would only then be reviewed and revised accordingly. The drawbacks of this approach can be costly.

In attempts to establish planning guidelines based on predictive models, librarians have turned for help to both information scientists and philosophers of science who have undertaken the examination and explication of knowledge growth, and whose investigations have been useful in explaining the behaviors of scientific literature and its producers. Numerous methods have been proposed in attempts to measure and explain such growth; although several of these methods

have been used by collection managers to provide data on acquisition planning for the sciences, these methods appear to have two basic drawbacks. First, a significant number of the investigations, which were made outside the field of information science, are highly theoretical, and they provide very limited empirical data. Second, many of the more quantitative studies do not provide a mechanism for discovering either why a particular body of scientific knowledge grows or what behaviors can be anticipated in the future; rather, they seek to establish the growth pattern itself. These basically ex post facto approaches are of limited use to the librarian who is trying to allocate extremely limited future resources.

In regard to acquisition planning, collection managers need a series of models that will provide the accurate predictive data on which to base future acquisition decisions. These models must move beyond an emphasis on past literature performance toward an orientation to present and future growth behavior. In order for the models to provide operationally useful data, they should deal with scientific knowledge at the specific subfield level, not at the broad discipline level, because acquisition decisions are made at this more narrowly defined level. The need for such models is especially acute in the new subfields for which data are unavailable on prior growth patterns.

Purposes of the Study

The purposes of this study were as follows:

1. To construct a model that reflects the relationship of research methods and growth within selected subfields;

2. To provide the necessary theoretical and operational foundations on which to base the model; and

3. To test the validity of the model using a set of ex post facto growth data.

Hypothesis

In order to test the proposed model, the following primary hypothesis was formulated. A correlation exists between characteristics of the research methods used in a subject subfield and the growth of the published literature of that subfield.

In order to refine the testing of this hypothesis, the following six control variables were utilized: (a) the listing of the primary author in the 1965 edition of the American Men of Science (1); (b) ranking of the quality of the primary author's graduate program in the Cartter Report (9); (c) ranking of the quality of the effectiveness of the primary author's graduate program in the Cartter report (9); (d) the geographic location of the primary author's employment; (e) the primary author's gender; and (f) the type of institution in which the primary author was employed.

Background and Significance of the Study

The major purpose of the present study was to investigate the relationship between characteristics of the research methods used in selected subject subfields and the growth of published research in those subfields. A number of possible variables were considered, among which are such scientometric measures as page counts, citations, and the number of articles in the subfield's journals. All of these were rejected as unsuitable because of their requirement for a considerable amount of ex post facto data. A model that uses such data would have a built-in time lag for its application to a new discipline or subfield; therefore, such a model would be of limited use in terms of acquisition planning. Research methods was selected as an appropriate variable around which to design the model because it is a variable that can be evaluated from a subfield's first recognized appearance. This decision is supportable both theoretically and operationally. On a theoretical level, there is sustained interest in the relationship between research methodology and the growth of science; such studies, although they generally focus on very broad discipline levels, provide considerable support for the close relationship of methods to scientific progress, and thus growth. On an operational level, a number of studies clearly demonstrate the potential of evaluating research utilizing research methods models. These approaches will be examined subsequently in detail.

This study combines the two approaches into a single model that, when validated, will provide a means for evaluating a body of research at the level of the original article. In addition to the model's practical utility, its development, testing, and validation also will add to the theoretical base of the relationship of research methods (the independent variable) to growth (the dependent variable) within the structure of scientific literatures. Further, a discussion of the theoretical and operational foundations of both the independent variable, research methods, and the dependent variable, growth, provides the necessary support for the major hypothesis of this study.

Background of the Independent Variable, Research Methods

Often, the basic question of how science, and thus knowledge, progresses and grows has centered on the methodological behavior of the scientists who engage in research. Investigators have considered how scientists organize their research behavior; on what logical premises (if any) they base their activities and conclusions; and how they choose their research problems. Laudan (40) designates the organization of these behaviors "research traditions," which he defines as "a set of general assumptions about the entities and processes in a domain of study, and about the appropriate methods to be used for investigating the problems and constructing the theories in that domain" (40, p. 81). Thus, Laudan notes,

a research tradition has a direct impact on progress and growth by strongly influencing the type and relative importance of both the research problems that can be addressed by its theories and the methods used in these investigations. A few brief examples of past and present research traditions will illustrate this point.

Differing but coexisting scientific research traditions have flourished for centuries. There were classical Greek scholars who favored the essentialist and instrumentalist approaches (41, p. 13) and those who were advocates of the experimental and observational methods (45). Seventeenth century philosophers argued the merits of the rational and the empirical approaches to research (58, pp. 136-137). The empirical approach has directly influenced modern scientists' conceptions of the elements that comprise quality scientific methods. The rational research tradition, however, continues to have significance and relevance in disciplines in which the research approach in certain subfields appears to be in transition.

Several modern theories which are advanced in efforts to explain and categorize scientific behavior and progress and thus research traditions focus on the various ways by which problems are selected and hypotheses are evaluated. Essentially, these are two sides of the same coin, but prior to hypothesis construction and testing, basic problem areas and their theoretical foundations must be isolated and

described. If this is not done, then valid hypothesis formation is impossible. Zuckerman (67) presents an excellent brief literature review of this process from the standpoint of sociological science. Conceptually, however, the treatment of hypotheses has split into two different schemes, confirmation and disconfirmation (64, pp. 115-128).

Kuhn (37, p. 19) questions how scientists select between competing theories, and, although he does not use the term, Kuhn essentially examines research traditions for an explanation and solution to this query. He concludes that the choice, rather than being selected on strictly empirical grounds, is primarily determined by psychological or sociological factors. In Kuhn's view, an understanding of this behavior requires "a description of a value system, an ideology, together with an analysis of the institutions through which the system is transmitted and enforced" (37, p. 21). In other words, the research tradition itself must be examined and evaluated. In addition to Kuhn's contention that scientists, who are in the normal phase of a normal-revolutionary cycle, tend to reject negative empirical evidence directed towards a favored hypothesis, he also stipulates that they do not leave the current theory behind until an alternative hypothesis is available. [Cole (14) and Lakatos (39) also support this concept of the necessity for a previously delineated replacement hypothesis.]

In contrast to models of scientific behavior, progress, and growth that are founded upon the concept of confirmation, several philosophers of science have constructed research tradition models that are based on hypothesis disconfirmation or skepticism. The major theoretician of this so-called hypothetico-deductive view is Karl Popper (53, 54, 55). [Other investigators who have adopted a basic disconfirmatory orientation are Eccles (19), Laudan (41), Platt (52), Sekuler (60), and Shapere (61).] Popper (54), in a direct comparison of the differences between himself and Kuhn (37), rejects the view that sociological factors (and by implication research traditions and growth) are of prime importance in the development of theories and knowledge. Also rejecting Kuhn's idea of a cycle of normal and revolutionary science, Popper holds that a constant critical evaluation of competing theories is taking place that utilizes the process of disconfirmation or falsifiability. In Popper's view, the use of falsifiability results in the "drawing of a line (as well as this can be done) between the statements, or systems of statements, of the empirical sciences, and all other statements . . . ." (55, p. 99).

Research methods also have been investigated on a more directly operational level in a series of studies that focus on the concept of measuring research quality by utilizing the evaluation of selected research methods criteria. Such investigations have generally taken two forms. In the first,

the author presents a list or narrative of his opinion of what constitutes quality research methods; there is no attempt at validation and usually no indication of how the particular criteria are selected. The studies of Fox (20) and Perdew (49) fall into this category. The major benefit of such efforts lies in their presentation of a broad overview of popularly accepted research methods evaluation criteria.

In the second form, the author also presents a set of recommended criteria, but, in addition, he develops and reports evidence regarding the validity and reliability of the instrument. Most such investigations also indicate how the selected criteria were chosen. Among the investigations of research methods criteria which are significant for this study are those by Gephart (23, 24, 25, 26), Persell (50) and Kohr and Suydam (36).

Gephart, in a series of studies relating to research methods evaluation, adopts the widely supported approach of conducting a literature search in order to identify a consensus of evaluation criteria that are organized into an evaluative checklist instrument or model. The instrument is used to assign an overall quantitative score to the research methods that are reported in a published paper; Gephart evaluates the methods, not the subject content of the paper. In contrast, Persell (50) uses the same basic criteria selection process, but she also attempts to evaluate the

contents of the paper. The literature search is also used to identify a consensus of research methods evaluation criteria by Kohr and Suydam (36); in this study, the literature provides a degree of face validity to the consensus set of criteria. Chapter II presents a detailed discussion of these studies as part of the foundation of the development of the model for this study.

Background of the Dependent Variable, Growth

Unlike research methods (the independent variable) much of the background support for growth (the dependent variable) is derived from the information science literature. For the most part, these investigations have been concerned with identifying the patterns of growth rather than with the more theoretically based question of why a particular literature does or does not grow. A brief review of selected studies will illustrate the various approaches to the study of growth.

A substantial number of these studies utilize scientometric techniques in order to develop growth models. Many growth models are based on the scientific journal as an appropriate bibliometric unit which was introduced as a measure in 1917 by Cole and Eales (11).

Within the parameters of these models, the growth of knowledge, especially scientific knowledge, is quantitatively measured in terms of the number of journals (and by implication, journal articles) that are published in various

fields (43, p. 6). Although the published literature is generally accepted as a valid measure of knowledge growth, Moravcsik (46) points out that this is not a strictly accurate judgement because all scientific knowledge does not appear in journals. In addition, he says that the different publication practices outside of the United States can result in difficulties if the scientific journal or paper is used as the base unit of measure.

During the 300 years following the appearance of the first scientific journals, there has been a rapid increase in the total number of journals. Price (57) remarks that the growth rate is in fact both continuous and exponential; "if any sufficiently large segment of science is measured in any reasonable way, the normal mode of growth is exponential. That is to say, science grows at compound interest, multiplying by some fixed amount in equal periods of time" (57, p. 4). He also notes that the same growth pattern holds true for the number of papers that are published in the journals.

Since some researchers disagree with Price's model of exponential growth, several other interpretive patterns have been proposed. Tague and others (63) present a concise overview of the proponents and their concept of exponential growth as well as of those who have reservations regarding its validity and usefulness. Even though Price presents considerable evidence to support his conception of past exponential growth, he observes that such growth cannot logically

continue.

> It is clear that we cannot go on another two orders of magnitude as we have climbed the last five. If we did, we should have two scientists for every man, woman, child, and dog in the population, and we should spend on them twice as much money as we had (57, p. 19).

Recognizing this necessity, Price predicted in the 1960s that there would be a decline in the rate of production of published scientific papers and journals. In 1974, King (35, pp. 13-14) observed that whereas the total number of scientists and engineers had increased an average of 3.8 per cent per year since 1960, by 1976 the rate was expected to drop to approximately 2.7 per cent; similarly, in terms of the dollar amount spent on scientific and technical communication, a rate of 6.6 per cent increase was found for 1960 to 1975, but a decrease to a rate of just over 3 per cent was projected for 1976 to 1980. Although it is generally accepted now that the exponential growth pattern cannot continue, Anderla (3, pp. 38-44) concluded in 1974 that the earlier rate was in fact continuing. Price (3, pp. 38-44) proposes one potential explanation for Anderla's conclusions; he feels that the reasons for an apparent continuance of the earlier growth rates are the increased participation of scholars from less-developed countries in the production of scientific information and an expanded definition of what constitutes science.

Kuhn has also investigated scientific growth, but Gaston reports that "Kuhn's is a model whereby the content of science

changes" (22, p. 476). Kuhn (37, 38) views science, and thus knowledge, as growing in a cyclic manner and manifesting two main phases that he calls normal and revolutionary science. With his approach, it is only during the revolutionary phase (non-confirmatory) that new theories appear and gain ascendency. At other times, science exists in a more regular or normal phase in which current popular theories tend to be accepted even in the face of substantial negative evidence (conformation bias behavior).

Such growth patterns and forecasts hold important implications for collection developers. Although the general patterns proposed by such investigators as Kuhn (37, 38), Popper (53, 54, 55), and Price (57) are of considerable theoretical and philosophical interest, they are of limited use in reaching actual acquisition decisions. To meet the latter need a more specific focus directed towards growth trends is required at the level of individual disciplines and specialized subfields. Gaston says, "The growth of knowledge is most visible at the problem area. Problem areas combine with other areas to make up a speciality. And in turn, many specialities comprise a discipline" (22, p. 488). By addressing this need to evaluate subfields rather than science as a whole, this study is designed to investigate the growth rates and research methods of two subfields.

Within the context of subfield investigations, the work of Menard (43) is of major significance. Menard examines the

relationship of scientific knowledge growth and manpower in terms of particular subject disciplines and subfields rather than of science as a single discipline. Of particular relevance, Menard investigates the behavior of the geological literature and its component subfields. The growth data generated in his study were utilized to test the proposed model of this study.

Acknowledging the contribution and validity of Price's (57) more general approach, Menard (43) recognizes that not all of science grows or declines at constant rates; some segments or fields tend to grow at varying rates, while others tend to decline or show no change. Although the variables underlying the differing growth rates are recognized as necessarily complex, Menard identifies and evaluates several variables which afford useful insights.

The size of the scientific population is one growth indicator which is identified by Menard. In his investigation, however, Menard (43, p. 74) found no strong relationship between the total output of geological publications and the number of geologists. Menard also reports little correlation between federal research-and-development funding and published paper output (43, p. 80), although a slightly stronger relationship was found between research paper output and basic research funding. He concludes,

> It appears that money is helpful, but an increase does not long sustain a proportional expansion of service, and level funding does not quickly suppress growth.

> How long exponential growth will continue if basic research is level-funded is another matter. American scientists tend to have enormous accumulations of undigested data, rooms full of virtually idle analytical equipment, and other winter stores that will sustain research output at a much lower level of funding for a while (43, p. 81).

Menard also identifies several variables that are concerned with what he calls the "scientific literature" (43, pp. 129-146); these variables are style, bibliographies, citations, jargon, and controversy. He hypothesizes that so long as a field maintains a normal growth rate, the resulting literature will manifest a normal content; if the growth rate slows, the content or structure of the literature will begin to change and rapidly cease being normal. After investigating all of these indicators of non-normal structure, Menard reports that they correlate well with dormant growth periods in the published literature of geology.

Menard (75) did not consider the research methods variable. To have done so would have required the examination and evaluation of the original literature. In common with most other bibliometric studies, Menard chose to utilize a set of ex post facto secondary level data. One purpose of the present study was to develop a method through which the potential growth behavior of a subfield could be initially determined at the original document level at the time of its appearance. Other bibliometric measures are proposed as the bases for a variety of growth models, but significant problems have been noted for each approach. Crane (16), like

Price (57), reports the use of a straightforward count of the number of published research papers as a growth measure. This technique was also used by Bradford (7), Cole and Eales (11), and Hulme (33). Although these studies, as well as others, help to establish the usefulness of a quantitatively based approach, the major problem with using straight paper counts, as Garfield (21) and Gilbert (27, p. 18) note, is the assumption that there is an equal amount of scientific knowledge in each paper, which raises the problem of subjectivity.

Regarding subjectivity, Moravcsik (46) notes that the differences in editorial and refereeing practices within different fields tend to preclude any assumptions about uniform quality. Gordon (29) argues that bias on the part of referees is a factor in the physical, social, and behavioral sciences, and Pinski and Narin (51) also report on the potential impact of referees. Isenberg (34) observes that editors of scientific publications can either promote or retard new ideas; therefore, they directly influence the growth and content of the literature.

The ability to restrict knowledge growth, in terms of publication and dissemination, through resistance to new ideas is not limited to editors and referees--it extends into the scientific community itself. Duncan (18) examines this phenomenon in a specific case of scientific discovery and concludes that resistance is firmly rooted in the social

nature of the scientific community. Amick (2), in an investigation of science as a social system identifies the roles that status and stratification play in knowledge growth. Michalos states the problem as follows:

> To a significant extent science is a set of accepted procedures; to be a good scientist is, in the first place, to master these procedures. Moreover, since a good scientist is a person with high status in the social hierarchy of the scientific community, and since high status is generally preferable to low status, from a purely personal or ego-enhancing point of view, most scientists would like to be regarded as good scientists (45, p. 238).

Ben-David (5) considers the social nature of science on a much broader national level and identifies competition as a major factor in the success or decline of scientific progress.

Crane (16) attempts to control for the subjective factors of bibliometric analysis by proposing (as a specific growth indicator) the initial appearance of a dependent or independent variable in the published literature; however, several significant problems have been detected in this measure. Gilbert (27, p. 20) identifies four problems. First, the appearance of a new variable can occur in both important and trivial contexts; second, the utilization of existing variables for significant new proposals may not be counted as innovation; third, old variables with different names might be counted; fourth, the method is best suited for use in quantitative fields that employ a stable terminology.

Although admittedly at a secondary-data level, citation counts are proposed as a more objective and accurate means of measuring both scientific growth and the closely related overall quality of a published body of work. The early efforts of Gross and Gross (31) helped to establish this technique in the literature; since that time hundreds of citation-count studies have been undertaken and reported. These investigations have resulted in substantial positive and limited negative support for the approach. Both aspects deserve review.

While a recognition of potential problems in the employment of citations has become a regular feature of the literature, the majority of citation studies tend to support the properly controlled usage of this indicator. Cole (12), in a widely cited study, reports that straight citation counts represent a good rough-quality measure; the validity of this bibliometric technique is solidly established, especially in terms of its close relationship to various prestige and eminence criteria. Clark (10), in a landmark study of psychologists, reports that citations displayed a stronger correlation with various indicators of prestige when compared to a straight count of the number of published papers by the sampled psychologists. Zuckerman (66), in a study of Nobel laureates, establishes a strong relationship between this, perhaps, ultimate eminence indicator and the laureates' citation counts. Myers (47), reporting on an investigation of

citations and prestige, concludes that citations represent a valid, quantitative, objective, and easily calculable index to eminence in psychology. Griffith and others (30) and Margolis (42) also have made substantive contributions to research in this area.

Other investigators have aided the establishment of the strong relationship of citations and quality in graduate education. Cole and Cole (15) found a high measure of agreement between the quality of academic scientists' work (measured by citation counts) and the prestige, and thus quality, of their departments. Anderson, Narin, and McAllister (4) based their significant study on a comparison of university ratings with publication ratings. Three bibliometric measures were employed, including the number of citations to a sample of papers. A strong positive correlation was found between university size and the citation quality of the publications that were produced by the university. Hagstrom (32), in his investigation of several correlates of departmental prestige in three natural and life sciences fields, for which he drew data from American Men of Science (1) and Science Citation Index (59), found positive correlations for citations to eminence in each of the fields examined.

In addition to studies that seek to establish citations as valid indicators of quality, other investigations focus on the use of citations and other bibliometric elements in evaluations of the growth of published literature. These analyses

constitute an attempt, within the discipline of information science, to establish the existence and validity of certain growth patterns. The most firmly supported analyses include "Bradford's Law", "Zipf's Law" and "Lotka's Law" for which excellent literature reviews on each can be found in Drott (17), Potter (56), and Wylls (65). These three models, each derived empirically (48, p. 12), represent basic laws of bibliometrics.

A major operational area of usage for these laws is with collection development and management even though their predictive capabilities depend, as with previously discussed models, on large ex post facto information bases that are derived from largely secondary data. This limitation does not, of course, completely eliminate their actual and potential uses in collection development for which Broadus (8) provides an excellent detailed literature review. Regarding collection development, Broadus concludes that "in the absence of highly expert subject specialists on a library staff, citation studies can be of considerable value in choosing serials and even monographs" (8, p. 328). However, as O'Connor and Voos note, "the widespread applications of practical bibliometric methods--useful to library managers--will continue to be limited until a more general, unified theory is developed" (48, p. 12).

While the validity of using citation counts as a bibliometric measure of growth and quality is generally accepted,

several researchers have limited reservations regarding its use. Persell (50) identifies and questions four areas of concern, each of which is related to assumptions about the basic objectivity of citations as a measure. First, it is assumed that there will be an equal level of visibility for each author. Second, the assumption is questioned that citation rates will be unaffected by such variables as geographic location and social prestige. Third, it is assumed that there will be a high level of agreement as to the use of quality standards. Fourth, also identified as an assumption is the concept that the citers themselves will be equally able to identify and evaluate quality. Smith (62) also identifies and evaluates the basic assumptions upon which citation analyses rest.

> 1. Citation of a document implies use of that document by the citing author . . . .
> 2. Citation of a document (author, journal, etc.) reflects the merit (quality, significance, impact) of that document (author, journal, etc.) . . . .
> 3. Citations are made to the best possible works . . . .
> 4. A cited document is related in content to the citing document; if two documents are bibliographically coupled, they are related in content; and if two documents are cocited, they are related in content . . . .
> 5. All citations are equal. (62, pp. 87-89).

Cole (12) also identifies four problems with the use of citations: (a) the potential for highly visible work not being cited, (b) critical rather than positive citations (and thus not quality), (c) the effect of subject field size on citation counts, and (d) the nonrecognition (and as a result the noncitation) of significant work. He reports that for

physics publications, none of these measurably affects the validity of citations as a quality measure. Cole and Cole (13) also outline the same set of problems as well as those that are inherent with the use of Science Citation Index (59), the source for most recent citation studies. These secondary problems revolve around the listing of only the first author and the presence of clerical errors. They conclude, however, that despite the possible obstacles to total accuracy, citations can be employed with validity as good, rough indicators of quality.

In an excellent review, Smith (62) reports that nine potential citation problem areas are multiple authorship, self-citations, homographs, synonyms, types of sources, implicit citations, fluctuations with time, field variations, and errors. She cites from the literature both positive and negative evidence for these problems and concludes that some of them are valid. She concludes, however, that "the limitations of citation analysis do not negate its value as a research method when used with care" (62, p. 93). In Broadus' review of the uses of citation analysis for library collection building, he concludes that "citation counts have considerable validity for assessing the quality of research produced by individuals and academic departments" (8, p. 328).

Assumptions

The following assumptions were made in the present study:

1. The research methodology that is reported in a study reflects the actual approach undertaken;

2. Quantitative bibliometric measures (such as citation counts) can be useful in establishing the qualitative nature of a body of research (such as that represented by a discipline subfield);

3. Growth rates of published scientific literature can be satisfactorily defined and measured using the bibliometric technique of page counting.

Limitations

The following limitations were recognized as operative for the present study:

1. A limitation is imposed on the generalization of the findings by the sample size of 244 articles, the restriction of two subfields, and the fact that the sample was drawn from a single two-year time frame from one indexing source;

2. The nature of ordinal data limited analysis to the nonparametric level, and the design of the study precluded the establishment of causal relationships;

3. The instrument, although validated within the context of the study, was designed to fit the particular subfields sampled and thus cannot necessarily be utilized effectively within other disciplines without revision.

Definitions

The following definitions are presented as they relate to this study.

Research is "The process of arriving at dependable solutions to problems through the planned and systematic collection, analysis, and interpretation of data" (28, p. 7). This rather broad definition was adopted in order to alleviate any potential biases toward highly formal empirical designs in the selection of the population.

Research methods "mean all the specific techniques used to secure, record, measure, or analyze the raw or original observations . . . ." (28, p. 9). This definition was adopted on the basis of its equal applicability to all types of research designs, such as experimental, historical, and survey.

The growth rate of the two subfields studied was based on the work of Menard (43) who established the rate utilizing the bibliometric technique of a straight-forward count of the number of papers indexed under selected subject headings in the Bibliography of North American Geology (6).

Summary

The purpose of Chapter I was to provide a background for the primary problem which is addressed by this study. The major hypothesis and the independent and dependent variables were introduced, together with supporting theoretical and operational foundations. In addition, the objectives,

operational definitions, assumptions, and limitations were also presented.

One of the major problems facing librarians is the selection of appropriate materials within the scope of extremely limited resources. In an effort to maximize these resources, collection developers have turned for help to the discipline of information science and its bibliometric techniques. Although such approaches can be effectively utilized in an effort to understand the past growth behavior of established disciplines and subfields, their dependence on large bodies of ex post facto data bases limits their utility in dealing with newly emerged subfields or with disciplines that are undergoing substantial changes which could result in significant growth pattern alterations. The purpose of the present study was to develop a model to test the hypothesis that a correlation exists between characteristics of the research methods used in a subject subfield and the growth of the published literature of that subfield. This model, if validated, could be used to fill the gap between the emergence of new subfields and the time required to generate the data bases necessary for the employment of established predictive bibliometric techniques. The model developed for this study attempts to bring together the earlier work, both theoretical and operational, that has been undertaken in the investigation of knowledge growth at a

broad-based level with document level research evaluation techniques.

Outline of the Study

Following the delineation of the problem and its background and significance as presented in Chapter I, Chapter II presents the methods and procedures of the study. The process of developing the evaluative instrument is examined in detail, with particular emphasis on the selection of appropriate evaluative criteria and the validation of the instrument. The justifications for the selection and utilization of the six control variables are also covered. Chapter III deals with the analysis of the data and the presentation of the findings. The external validation of the evaluative instrument is considered in detail. Chapter IV presents the summary and findings of the present study, along with generalizations of the findings, implications of the study, the relationship of the findings to other studies, and recommendations for further study. Seven appendices are incorporated to document the findings and support the study. Appendix A contains the original draft version of the evaluative instrument. Appendix B consists of the opinion validation version of the instrument. The final version of the instrument constitutes Appendix C. Appendix D contains the original data for the study; each sample is listed along with its individual score on both the evaluative instrument and the citation count to the article. Appendix E presents the retest scores

that were generated as part of the instrument evaluation process. Univariate frequency distributions for the variables analyzed during the conduct of the investigation are in Appendix F. Appendix G presents bivariate and trivariate frequency distributions for the independent, dependent, and control variables.

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CHAPTER II

METHODS AND PROCEDURES

Population and Sample

The population of interest for this study was defined to include all research articles in geochemistry and vertebrate paleontology that are indexed in the 1965 and 1966 editions of the Bibliography of North American Geology (4). This standard reference tool has been published by the United States Geological Survey since 1886. The indexed literature is listed in alphabetical order by author, and a combined subject and geographic index is included in each volume.

By definition, geochemistry is the science which studies

> (a) the relative and absolute abundances of the elements and of the atomic species (isotopes) in the earth and (b) the distribution and migration of the individual elements in the various parts of the earth (the atmosphere, hydrosphere, crust, etc.) and in minerals and rocks with the object of discovering principles governing this distribution and migration (18, p. 120).

Paleontology is that science which investigates organisms that once lived on earth; vertebrate paleontology is concerned with organisms that possess vertebrae. Both geochemistry and vertebrate paleontology are viewed as auxiliary geological sciences. Geochemistry links chemistry with general and applied geology, just as vertebrate paleontology links biology with general and applied geology. These specific subfields

were selected for this study on the basis of a prior investigation by Menard (27).

Working in the late 1960s, Menard (27) reported that for the period 1965-1966, the two subfields of geochemistry and vertebrate paleontology were growing at substantially different rates. He established these results by utilizing a straightforward count of the number of papers indexed under selected subject headings in the Bibliography of North American Geology (4). The subject headings employed were chosen for their stability over time in both terminology and concept. Menard concluded that geochemistry was growing rapidly; it displayed a doubling period of five to ten years. Vertebrate paleontology, however, was growing much more slowly; it displayed a doubling period of approximately thirty-five years (27, pp. 54-56).

The sample for the present study consists of 244 published research items that were drawn from the stated population. The following procedure was employed to select the sample.

1. Using the subject headings established as appropriate for the two subfields by Menard (27, p. 54), all entries under these headings in the 1965 and 1966 Bibliography of North American Geology (4) were recorded on individual cards. The headings used for geochemistry were isotopes and geochemistry, while those used for vertebrate paleontology were man, mammalia, and reptilia.

2. All duplicates, books, chapters in books (except proceedings), abstracts, theses, and nonresearch items were removed. This left a survey population of 621 research items.

3. Using the algorithm

$$n = \frac{N}{1 + Ne^2}$$

where n = sample size, N = total population, and e = error, a sample size of 244 items at e = .05 was determined (10, p. 232; 42, p. 549).

4. A stratified sampling design was used to organize the survey population into equal sized homogeneous subsets. Each item in the survey population was assigned a unique number. One range of numbers was used for geochemistry and one for vertebrate paleontology. A table of random numbers (32, pp. 301-304) was employed to select a sample of 122 items from each subfield.

5. A photocopy of each item was secured either from the collections of the University of Tennessee at Knoxville or through interlibrary loan. Each selected item was then examined in terms of its methodological content.

One basis for the selection and sampling of two geology subfields (in addition to their differing growth rates) is the concern that geologists have expressed regarding the different modes of research methods available to the field; by implication, they have been examining their research traditions. Writers in the field use the terms rational (qualitative)

and empirical (quantitative) in considering the different research traditions utilized by geologists. Mackin (26) reports that for most of its history geology has operated under the guidelines of a rational research methods approach. It was left to the individual geologist's own imagination to devise numerous possible working hypotheses (7). Instead of emphasizing the need to record and communicate precise measures and methods in the published literature, the typical geologist emphasized the use of experience and personal knowledge in the deduction or formulation of possible explanations for phenomena (26).

As used in the geology literature, the term empirical generally equates with a quantitatively based research tradition in terms of research methods and knowledge growth. From the viewpoint of geology as a historical science, Hempel states,

> In history and anywhere else in empirical science, the explanation of a phenomenon consists in subsuming it under general empirical laws; and the criterion of its soundness is not whether it appeals to our imagination, whether it is presented in suggestive analogies, or is otherwise made to appear plausible . . . but exclusively whether it rests on empirically well confirmed assumptions concerning initial conditions and general laws (19, p. 35).

It has been suggested (26) that the rational approach is more appropriate than the empirical approach to the needs of the field of geology because geologic systems are composed of large numbers of highly complex variables and because precise measures of variables can be extremely difficult to establish.

While this objection to the empirical (quantitative) approach has merit, it should be noted that numerous other fields (e.g., sociology and anthropology) also contend with complicated variable systems and measurement problems. Practitioners in these other fields have attempted to establish a research tradition that achieves a valid compromise between the rational and the empirical and that retains the needed qualities of both; the basic concepts of the rational (several working hypotheses, reason, personal experience) are combined with those of the empirical (quantification, dependence on the reporting of prior work, and the precise recording and reporting of procedures, analyses, and results).

The present study attempts to investigate the degree to which the two geology subfields manifest this shift from the rational towards the empirical. If the major hypothesis is supported, a field that displays a higher degree of an empirical tradition in its research methods will also exhibit a more rapid growth rate. This hypothesis is suggested by Platt (34) in a more restricted form. In order to test this idea in the present study, a research methods evaluation instrument was developed and used to obtain a quantitative assessment of the sample research articles in terms of appropriate methodological criteria.

Background for and Development of the Instrument

The strategy of conducting a literature review in order to identify, define, and isolate potential evaluation criteria is an accepted procedure in the area of research methods evaluation instrument construction. The contributions of Gephart (14, 15, 16), Persell (33), and Kohn and Suydam (22) are especially noteworthy; each constructed and quantitatively tested instruments developed by this strategy. A research methods evaluation instrument was developed, tested, and utilized in the present study by using the foundation laid by such prior researchers.

Gephart has reported several significant studies in the area of research methods evaluation. In 1965 he designed a rating instrument composed of fifty items and an overall evaluation measure to be used with the instrument in evaluating educational research (15). The instrument consists of a checklist of evaluation criteria categorized by (a) problem, (b) related research, (c) design, (d) analysis of data, and (e) conclusions and implications (15, p. 234). Several of the specified evaluation criteria imply an orientation toward experimental methods. The reliability of the selected criteria was tested utilizing a panel of ten subject specialists who read and evaluated selected articles taken from five counseling journals.

Gephart (16) has also considered research methods evaluation from the points of view of historical, descriptive, quasi-experimental, and experimental methodologies. Each was analyzed in terms of how it relates to the facets of measurement validity, unit representativeness, and administration of treatment. The author reports that although each methodology reflects all the facets, the treatment of the facets varies from methodology to methodology. Using a so-called Facet Design Technique, he developed four methodology profile sets, each with two levels. The results clearly indicate that consideration must be given to the basic type of research design used when research methods are evaluated.

Research methods evaluation criteria are again considered by Gephart in a third investigation (14). Based on an extensive review of educational research literature, he found a consensus that evaluative criteria relating to the following areas should be identified and utilized: (a) the problem studied, (b) the hypothesis tested or questions asked, (c) the related literature surveyed, (d) the design of the study, (e) the analysis of the data, and (f) the conclusions and implications drawn from the study (14, p. 12). Guided by his literature survey, the author next identified specific criteria within each area which he synthesized and formulated as follows.

Problem Studied

1. Does the researcher establish the existence of a problem?
2. Does the researcher develop a theory or conceptual framework for the problem?
3. Does the researcher describe the specific goals to be achieved?
4. Does the researcher state the limits within which the study is conducted? (14, p. 20).

Hypothesis Tested or Questions Asked

1. Does the question seek either the identification or nature of variables in a given problem?
2. Is the variable in each question observable?
3. Is the question related to the existing body of knowledge? (14, p. 22).

Related Literature Surveyed

1. Does the research report present a list of the studies completed in both the substantive and methodological aspects of the problem?
2. Does the research report [present] a critique of the studies listed?
3. Does the research report include a synthesis of what is known in both the substantive and methodological aspects of the problem? (14, p. 25).

Design of the Study

1. Does the research report define the population of people, things, or occurrences inherent in the problem?
2. Does the research report describe the sample selection procedures and/or the characteristics of the sample?
3. Does the research report operationally define the variables studied and the variables known to be associated with the problem?
4. Does the research report describe the controls necessary to counter the effects of the latter group of variables?
5. Does the research report specify optimally valid reliable data collection devices or techniques? (14, p. 27).

Analysis of the Data

1. Does the research report [present] systematically the accumulated data?
2. Does the research employ appropriate statistical procedures in analyzing the data? (14, p. 32).

Conclusions and Implications

1. Does the report state whether the findings confirm or disconfirm the hypothesis?
2. Does the report state the conclusions drawn from the findings?
3. Are the conclusions drawn from [but] without going beyond the data?
4. Does the report describe implied modifications in theory raised by the conclusions?
5. Does the report state specific problems raised by the investigation that require additional research? (14, pp. 33-34).

Persell (33) has developed and tested a rating instrument for assessing both the methodology and the substantive contribution of research studies. Like Gephart, she selected individual evaluative criteria for inclusion in the instrument based on a literature review. These criteria (each scored on an ordinal scale) were synthesized and formulated as follows:

Statement and Justification for Orienting Ideas

1. Delineation of initial concepts (or major dimensions of study);
   a. Conceptual terms are clear, including technical ones;
   b. Presentation is in orderly, logical sequence;
2. Specification of objective (specific problems or hypotheses to be investigated);
   a. Objectives are stated explicitly;
   b. The rationale for pursuing the objectives is indicated;
   c. The rationale for pursuing the objectives is justified;
3. Relationship to existing knowledge;

a. Relationship to existing knowledge is indicated (e.g., extension, specification, filling in gaps, etc.);
b. Relationship to existing knowledge is apt;

4. Significance of questions raised;
   a. Answers to questions raised would make a significant contribution to a theoretical question;

Research Design and Execution

1. Description of design
   a. The nature of each "case" is described sufficiently for replication of the study;
   b. The measuring devices (indicators, indices, etc.) representing the major concepts
      (1) are described;
      (2) are valid (i.e., neither exceed nor underrepresent the concepts);
   c. The population to which the sample or case may be generalized;
      (1) Is described or clearly obvious;
      (2) Is an appropriate population in terms of the study's objectives;
   d. The size of the sample is stated;
   e. Any subgroup comparisons are built into the design, and logical bases for these comparisons are described (as in experiments, longitudinal or panel studies, stratified survey samples, or comparative case studies);
2. Execution of the study design;
   a. In the collection of the data;
      (1) The initial sample was representative;
      (2) Measures were taken to insure maximum response rate from the sample or, as in longitudinal studies, to keep differential loss of subjects to a minimum;
      (3) The type of sample or selection procedure utilized was appropriate to the objectives of the study (e.g., cluster sampling, stratified sampling, snow ball sampling, frequency distribution matching, etc.);
      (4) The following problems were dealt with where necessary;
         (a) Statistical regression effect;
         (b) Selection bias;
         (c) Interaction effects of selection biases and the experimental variable;
         (d) Instrumentation effect;
      (5) Is the research design longitudinal, panel, or experimental;

(a) Maturation effect (changes due to passage of time);
(b) Testing effect (experience of earlier test affects results of later tests through cueing, etc.);
(c) Sensitizing effect of pre-test or first interview (affects subject's responsiveness to subsequent stimuli or events);
(d) Artificiality of setting or subject's knowledge that he is participating in an experiment;
(e) Multiple treatment effect (caused whenever multiple treatments are applied to the same subjects because effects of prior treatments are not usually erasable);
(f) Possibility of selection-maturation interaction, selection-testing interaction, or selection-instrumentation interaction;

(6) Any other possible weaknesses in the design;
(a) Are acknowledged;
(b) Are dealt with;

b. Analytical strategy of the author;
(1) Data is organized according to major concepts which have been introduced;
(2) Principal variables which have been measured are handled in such a way as to:
(a) Reveal distributions, relationships, effects, or comparisons bearing on hypotheses or problems;
(b) Discount uncontrolled factors which might be affecting the results (or spurious relationships resulting from a third variable which independently affects both variables in a given relationship;
(c) Specify relationships between two or more variables by showing the conditions under which the relationships are stronger or weaker, where needed;

c. Analytical techniques of the author;
(1) Use of statistics
(a) Statistical techniques are appropriate to the purposes of the study;
(b) Tests of significance are used appropriately for the sample design and for the nature of the data. If not used the decision not to use them is justified by the purpose or design of the study.
(2) Qualitative analysis (e.g., informant interviewing, observation, case studies, documentary analysis, etc.);

(a) Qualitative analysis is used where needed;
(b) Qualitative analysis is carried out properly.

Presentation of Data

1. Scope of presentation;
   a. All of the data specified in the design as being relevant to the study's objectives is presented or summarized;
2. Clarity of presentation;
   a. Topics or points are organized in a logical, coherent sequence;
   b. Technical terms are appropriate.

Aptness of Interpretations

1. Conclusions are appropriate to the data;
2. Data make a useful contribution to the theoretical or practical problems posed by the research;
3. Data which do not support the hypotheses, common expectations, or previous findings are acknowledged;
4. Implications for future research are mentioned (33, pp. 378-388).

Persell tested her instrument by having a panel of subject experts use it in evaluating a sample of research studies in education. In addition to criteria of reliability and validity, she considered the ease of administration of her instrument, and she also employed an overall summary measure of research quality reflecting the assessment of the following three global dimensions (using a five point scale for each dimension for a maximum total of 15 points): (a) substantive contribution to theoretical knowledge in education or to a discipline, (b) substantive contribution to any field(s) of educational practice, and (c) utilization of (or contribution to) research methods (33, p. 80). The validity of the

instrument was assessed in two ways: first, "by comparing the nominal and operational definitions of the concept" of research quality, and second, "by comparing two operational measures of a concept to see if they classify the phenomena being studied in similar fashion" (33, p. 83). In the second of these two tests, Persell compared the overall summary measure scores with the scores obtained from her detailed rating instrument. This resulted in a rank correlation coefficient of .81 between the two sets of rankings of the individually evaluated articles (33, p. 84). The present study uses a similar validation procedure by correlating research quality, as indicated by citation rates to the sample items, with an ordinal score for the same sample items, which is derived from the research methods evaluation instrument.

Kohr and Suydam (22) developed a more limited methods evaluation instrument that is restricted to survey research. Following the pattern of prior researchers, they identified and selected individual criteria based on a literature review. These criteria were formulated in terms of the following questions (each of which is scored on a five point scale).

1. How practically or theoretically significant is the problem?
2. How clearly defined is the survey problem?
3. How relevant and how well defined is the population?
4. How adequate are the sampling procedures?
5. How adequately are the sources of error controlled?
6. How adequate are the measuring instruments?

7. How appropriate is the statistical analysis of the data?
8. How reasonable are the conclusions drawn from the data?
9. How adequately is the research reported? (22, pp. 79-81).

In addition to the above investigations and other similar contributions, textbooks on research methodology represent a major source for relevant evaluation approaches. Among the numerous useful works available are those by Best (3), Borg and Gall (5), Mouly (31), Tripodi, Fellin and Meyer (40), and Van Dalen and Meyer (41). Although, generally, their instruments or narrative criteria are reported as untested, these works are significant because, in book form, the more subtle implications of research methods evaluation can be examined and discussed fully. This point is especially applicable in regard to the implications of research design and the special problems in particular fields.

In developing a research methods evaluation instrument for the present study, a preliminary set of twenty-nine evaluative criteria (see Appendix A) was selected utilizing the empirically supported strategy of a literature review as referenced above. This initial set of criteria represented a general consensus as revealed by the literature. A revised set of twenty criteria was distilled from the preliminary group (see Appendix B), which resulted in a second more concise draft of the instrument that includes, generally,

the same evaluation concepts. At this point in the instrument development process, the effort was focused on the identification of a set of criteria reflecting a basic literature consensus, rather than on a set adapted to the peculiar methodological requirements and limitations of the two subfields under study.

The next step in the process was to submit the second draft of the instrument to a panel of five instructors of courses in research methods for evaluation and suggestions. Each member of the panel is identified in the 1981 directory issue of the Journal of Education for Librarianship (12) as a full-time faculty member of an accredited graduate program in library and information science who reported research methods as a teaching area. The panel's overall purpose was to aid in the developmental process rather than to provide a final validation consensus measure. As such, it was not a requirement that a certain percentage of the judges question a particular criterion in order for that criterion to be reviewed, refined, eliminated, or retained in its original form.

In order to trace the evolution of the completed instrument from this draft, it is useful to examine the specific comments of the judges on the suggested criteria. In the following, the criteria items are underlined; the judges' remarks follow by separate or grouped items.

1. Is the purpose of the inquiry noted?

All five judges marked this item as appropriate.

2. Is there a review of the literature?

3. Does the review of the literature have a theoretical component?

4. Does the review of the literature have a substantive component?

5. Does the review of the literature have a methodological component?

6. Does the review of the literature have a critical component?

In the case of items 2 through 6, three judges stated that all are appropriate; one stated that items five and six appear to measure the same phenomena; the remaining judge remarked that the presence of five literature-review items could produce a weighting problem, and that items 3 through 6 appeared to be intangible.

7. Are the variables explicitly identified?

Four judges marked this item as appropriate; the fifth was concerned that it might not be appropriate to all research designs.

8. Is at least one hypothesis or question stated explicitly?

All the panel members indicated that this item is appropriate to the study.

9. Is more than one hypothesis stated explicitly or implicitly to explain the same phenomena?

Four judges marked this item as appropriate; one was dubious as to its value, expressing doubt that more than one hypothesis could focus more meaningfully on a topic than the use of a single hypothesis.

10. Are rival explanations for a dependent phenomena eliminated through testing within the context of the inquiry?

All the panel members marked this criterion as appropriate, but two suggested changes in the wording; one proposed adding the phrase "where possible-feasible" to the end; another suggested adding the phrase "or controlling variables" between the words "testing" and "within".

11. Is the population explicitly identified?

Four judges marked this criterion as appropriate; the fifth felt that the concept is probably more appropriate to the social sciences than to geology.

12. Is the sample explicitly identified?

Three panel members marked this criterion as appropriate; one suggested changing it to read, "Is the sampling technique and resulting sample explicitly identified"; the fifth judge indicated that this concept is probably more appropriate to the social sciences.

13. Was the sample selected randomly?

Three judges indicated that this item is appropriate, and four offered comments; one suggested adding the phrase, "if appropriate"; another proposed adding "or if not, was the superiority of a selected sample explained?". One judge

questioned the need for random selection in geology, while another commented that the concept is probably more appropriate to the social sciences.

14. Is a hypothesized relationship or a question tested through direct observation?

Four panel members marked this item as appropriate, and three elected to make comments; one noted that the question is unnecessary since an affirmative answer was assumed "in the kind of research you are examining"; one stated that the item is not fair for an historical study; the remaining suggestion was to add the phrase "if appropriate".

15. Are mediating variables both identified as such and controlled for within the context of the inquiry?

Four judges indicated approval of this item; one suggested adding the phrase "where possible"; one panel member stated that this item duplicates item 10.

16. Are data analyzed using statistical methodology?

Three judges found this criterion as appropriate to the study; one suggested adding the word "appropriate" between "using" and "statistical," and the phrase "when needed" at the end, and he indicated that the item is unfair in historical studies; one panel member commented, "While I can conceive of some kinds of research in this area employing stat, I doubt there is a large body".

17. Are all the stated hypotheses or questions accounted for in the results?

18. Are all of the stated conclusions drawn from the findings of the inquiry?

All five panel members marked items 17 and 18 as appropriate to the present study.

19. If the findings require a change in the theoretical foundations of the inquiry, is it explicitly discussed?

All of the judges indicated that this item is appropriate; one made the comment "very important," while another asked, "anything about its generalizations capacity?"

20. Are suggestions for additional inquiry stated?

Four judges stated that this item is appropriate; the fifth commented that "this would depend on the nature of the study--descriptive or theoretical."

Following the examination and evaluation of the individual criteria, each judge was given the opportunity to offer overall comments on the instrument; four of them chose to do so. One judge simply restated his earlier comments. Another judge remarked that not all of the items are of equal value, making an ordinal score of "questionable utility"; he suggested the employment of some type of weighting technique. Another panel member questioned the use of nominal data to establish an ordinal scale. The remaining judge restated his opinion that the criteria were drawn heavily from the social sciences and that paleontology might not fit the proposed model. Following the receipt of the above evaluations, the final version of the instrument was developed.

Before discussing the actual instrument, it may be pertinent to explain why several specific evaluation items were not included. Three of the five initial items that dealt with the literature review were eliminated. One dropped item was the straightforward, "is there a review of the literature?" The other two dropped items dealt with methodology and substantive components. The elimination decision was based on three points. First, as one of the judges noted, the inclusion of five closely related items could pose a weighting problem. Second, the presence or absence of a review of the literature was deemed to be implicit in responses to the two retained literature items. Third, based on the responses of the judges, the remaining related criteria were judged as sufficient for the purposes of the instrument.

The criteria concerning random sampling and an explicit population definition were also excluded. The initial assumption was that a specific population should be defined and that a sample or samples should be selected using some kind of formal sampling design. It was concluded, however, that this could be inappropriate within the context of the present study. Although there are significant problems in applying such a technique to both subfields, the problem is acute in the case of vertebrate paleontology. For example, fossil deposits (the sample in paleontology) may be initially located through fortuitous accident; perhaps a farmer who is plowing a field will uncover a fossil deposit, or road construction

will accomplish the same end. Even when, as is increasingly likely using modern techniques, the paleontologist approaches a site with an informed expectation of locating fossils in a given area, it is rarely with the stated intent of drawing a sample in a conventional sense from a precisely identified population. The justification for the exclusion of a criterion centered on random sampling is based on a similar argument. While it is possible to conduct random sampling in both subfields, the technique often is of limited practical value. When such sampling does take place in paleontology, it usually happens in the laboratory, and thus long after the discovery, recovery, and description of the sample in the field.

The criterion designed to evaluate a study's replicability was also excluded. As before, this decision resulted from methodological restrictions to the two subfields. While individual measurements may be replicated in paleontological research, duplication of the entire design is generally impossible. Likewise, measurement replicability poses significant potential problems in both subfields since several commonly utilized techniques result in the destruction of part of the original sample.

It was further decided to exclude criteria concerning titles, abstracts, graphs, maps, illustrations, etc., since these were judged to be essentially editorial in nature and not directly linked to methodological elements. For the same

reason, such items as style, organization, and clarity of meaning were also excluded.

The final instrument includes nineteen research methods evaluative criteria (see Appendix C). These criteria are formulated as separate items that are designed to be answered with either yes (1) or no (0) and thus to yield a total ordinal point score ranging from zero to nineteen. Each of the nineteen criteria items is listed in the following enumeration, together with indications of support for their selection. In citing supporting references from the literature, the purpose is not to enumerate every support that was identified in the literature review, but rather to present a small number of representative sources. It should additionally be noted that the citations are to the concept underlying the criterion rather than to any particular wording or phrasing.

1. Is the purpose of the inquiry indicated?

This criterion received unanimous support in the literature.

2. Does the review of the literature have a theoretical component?

This criterion reflects the basic understanding that the communication of prior research and theory is essential to the growth and cumulation of knowledge. In addition to the support of Cole, Kuhn, Platt, Popper and others as referenced in Chapter I, considerable support from the research method

evaluation literature is found in the works of such authors as Gephart (14, p. 24) and Persell (33, p. 379).

3. Does the review of the literature have a critical component?

As with criterion 2, this item and its underlying concept have substantial literature support. Both Lakatos (24) and Popper (34) support the idea that if there were no critical component in the literature review, the reader would be left to assume that the cited studies have no significant faults, biases, limitations, etc. If the reader were not willing to make this assumption, he would have to expend considerable effort to check the literature himself. The critical component in the literature review is needed both to justify an investigation and to place it in relation to other studies. Substantial support of this criterion also is found in the methods evaluation literature in the works of Best (3, p. 337), Gephart (15, p. 241), Mouly (31, p. 343), and Van Dalen and Meyer (41, p. 444).

4. Is the sample identified with precision?

This criterion concerns whether the sample is identified as such and described with sufficient precision to facilitate interpretations and to qualify generalizations. Support for the concept of precise sample description is found in the evaluation work of Borg and Gall (5, p. 503), Michael (29, p. 408), Persell (33, p. 381), and Van Dalen and Meyer (41, p. 449).

5. Is the rationale or method of sample selection explained?

The formulation of this criterion was determined both by the opinions of the panel members and by a recognition of the operational realities in the two subfields. It should be noted that this criterion does not require conventional probabilistic or randomized sampling. Rather, it concerns whether the sampling methods used are described and explained in relation to the kind of research problem addressed. The literature support for this criterion includes Borg and Gall (5, p. 502), Gephart (15, p. 241) and Persell (33, p. 382).

6. Are the individual variables described numerically?

This criterion concerns whether the variables under study are quantified or described in numeric terms. An affirmative scoring on this item reflects some type of data quantification. For example, instead of reporting that "this sample contains a great deal of X" or "this sample is unusually small," it might be stated that "this sample contains 2 mg of X" or "this sample is .003 mm long." No direct comparison of different measurements is required by this criterion. Within the geological methodological literature, support for this concept is found in the work of Miller (30, pp. 440-441) and Till (39, p. 6).

7. Are possible mediating variables noted?

This criterion is strongly supported throughout the research methods evaluation literature. The necessity for at

least acknowledging such variables (which, although not necessarily analyzed, could affect the relationships under study) receives backing in the works of Best (3, p. 377), Borg and Gall (5, p. 503), Gephart (15, p. 242), Persell (33, p. 282), and Van Dalen and Meyer (41, p. 452).

8. Are the data analyzed using statistical methodology?

This criterion concerns whether statistical methods are used in analyzing empirical data in order to answer a research question or to support a research conclusion. Formal inference procedures are not required, and no attempt is made to evaluate the type of statistical analysis utilized. An implication of the major hypothesis is that a subfield which has moved further towards the empirical approach (as this term is used in the geology literature) also will display a more rapid growth rate. The use of statistical analysis is viewed as a direct indication of such a move. Within the general research methods evaluation literature, support for this criterion is found in the works of Best (3, p. 378), Krumbein (23, p. 385), and Persell (33, pp. 2-6).

9. Are the data on different variables related to each other numerically?

Like criterion 8, this criterion concerns the degree to which data were analyzed and reported with precision. However, an affirmative response to this criterion requires only the presentation of some type of direct comparison of numerical data but not necessarily involving statistical analysis.

An example would be that "sample X contains .02 mg of Z, whereas sample Y contains .01 mg of Z"; no statistical analysis of the data is required. Support for this criterion is found in the works of Miller (30, p. 441) and Till (39, p. 6).

10. Is there at least one explicit or implicit hypothesis or research question?

This criterion is heavily supported in the research methods evaluation literature, including such investigators as Best (3, p. 4), Gephart (14, p. 32), and Mouly (31, p. 343). Earlier versions of the instrument required an explicit statement of an hypothesis or research question, but this was changed in the final version to allow for an implicit hypothesis or question whenever clearly evidenced by the structure and conclusions of a study.

11. Is at least one hypothesis-question tested?

Best (3, p. 157) and Van Dalen and Meyer (41, p. 2) provide literature support for the inclusion of this criterion. One of the panel members remarked that this criterion is implicit in the type of research being examined, but the concept of research utilized in the present study does not require the testing of a hypothesis or research question; some research investigations might be essentially descriptive in nature, while others might pose hypotheses or research questions without seeking to test them.

12. Are multiple hypotheses proposed to explain the same phenomena?

The general concept of the utility of multiple hypothesis in research methods is supported by Lakatos (25), Popper (35), and others. In addition, the idea has longstanding support in the geology literature. In 1897, Chamberlin stated

> In developing multiple hypotheses, the effort is to bring up into view every rational explanation of the phenomenon in hand and to develop every tenable hypothesis relative to its nature, cause or origin, and to give to all of these as important as possible a working form and a due place in the investigation (7, p. 843).

In 1886, Gilbert observed that

> . . . [The researcher] is not restricted to the employment of one hypothesis at a time. There is indeed an advantage in entertaining several at once, for then it is possible to discover their mutual antagonisms and inconsistencies, and to devise crucial tests--tests which will necessarily debar some of the hypotheses from further consideration. The process of testing is then a process of elimination, at least until all but one of the hypotheses have been disproved (17, p. 286).

13. Are multiple hypotheses tested to explain a single phenomena?

The support for the inclusion of this criterion is essentially the same as that developed for criterion 12.

14. Are assumptions identified as such?

This criterion receives heavy support in the methods evaluation literature. Specific examples of support can be found in the works of Best (3, p. 377), and Tripodi, Fellin and Meyer (40, pp. 74, 83, 89). A formal statement of

assumptions allows the reader to make more informed judgements regarding the worth and usefulness of the research being examined.

15. Is the procedure(s) used to investigate the hypothesis described with precision?

This criterion requires the provision of a precise description of the procedures utilized in a study. The description should be sufficient to support the evaluation of the study and to permit the replication of the study, if desired. Within the evaluation literature, support is found in Borg and Gall (5, p. 453), Persell (33, p. 384), and Van Dalen and Meyer (41, p. 157).

16. Are limitations of the inquiry noted?

Just as criterion 15 concerns the need for the precise reporting of procedural details, this criterion concerns the requirement for communicating any limitations that may affect a study. If such limitations are not formally noted, the reader is left without an adequate basis for assessing the scope of a study, for interpreting its findings, or for qualifying its conclusions. The works of Fox (13, p. 285), Kohr and Suydam (22, p. 81), and Mouly (31, p. 2) also lend strong support for the inclusion of this criterion.

17. Are the conclusions based on the findings of the inquiry?

This criterion concerns the extent to which the conclusions of a study are logically based upon the procedures and

findings of the reported investigation. If the conclusions are not so based and limited, the reader is left to wonder about the integrity and the usefulness of the published research. Support for this criterion in the evaluation literature is found in Best (3, p. 378), Gephart (14, p. 244), and Mouly (31, p. 344).

18. Are the findings' possible impacts on theory acknowledged?

This criterion concerns the extent to which formal linkages are drawn between the reported research findings and the theory that forms the foundation of that research. If such linkages are not made within the context of the reported study, the reader will be forced to draw his own conclusions about theoretical implications. Cole (9), Kuhn (24), Lakatos (25), and Popper (35) support the essential nature of this criterion, as do Mouly (31, p. 344), and Tripodi, Fellin and Meyer (41, p. 93).

19. Are recommendations for additional inquiry stated?

The purpose of this criterion is to determine whether the researcher provides guidance in pursuing further investigations. If this were done, as Platt (33) recommends in identifying relevant branches of a strong inference tree, the continuance of research (and thus the growth of knowledge) can proceed in a fairly straightforward manner. If, however, the reader were required to consider the prospect of further research without such guidance from the earlier investigation,

the potential for wasted effort would be increased. Within the research method evaluation literature, this criterion is supported by the works of Gephart (15, p. 52), Michael (29, p. 409), and Persell (33, p. 388).

Data Collection and Instrument Validation

The data collection process was as follows.

1. The document number of each sample item, the primary author's name as it appears on the sample item, the name of the source publication, the volume number, date, and page numbers were recorded on a citation rating form;

2. Science Citation Index (38) was utilized to obtain a citation count for each sample item (excluding self-citations). The count was made for a period of five years that began one year after publication. A total citation score was recorded for each document;

3. Each sample item was read and scored by the author of the present study using the research methods evaluation instrument. As a check on evaluator reliability, a random sample of twenty-six of the items were subsequently rescored, and the results of the two scorings were compared. (Appendix D lists each sample item showing (a) document number, (b) bibliographic citation, (c) evaluation score on rating instrument, and (d) citation score from Science Citation Index.)

4. The name of the primary author as it appears on the sample item was recorded on an author data form. The 1965 edition (with supplements) of American Men of Science (1) was used to record information on the three control variables, (a) gender of primary author, (b) listing of primary author in American Men of Science (1), and (c) the institution and department that granted a doctoral degree to the primary author. The data for two additional control variables were collected from the sample item. These two variables are the geographic location of the primary author's employment, and the type of institution at which the primary author was employed. The data for the final two control variables were recorded by using American Men of Science (1) to determine if an author was listed as having the doctoral degree, and if so, from what institution. When the individual was listed as having the degree, the granting institution was checked against the Cartter report (6) for the ranked quality of the graduate faculty and the effectiveness of the graduate program. The rationale for the utilization of these six control variables will be discussed further

5. The instrument was validated by computing a Kendall tau correlation coefficient based on the ranking of the evaluation score of each sample item with the citation count for that item.

Control Variables

The major purpose of the present study was to examine the relationship between the research methods used in the published research of a subfield and the growth rate of the published literature of that subfield. In the subsequent analysis of this relationship, six potential extraneous variables were isolated and defined. All six selected variables represent potential indicators of prestige or eminence. The concept that prestige can play a role as a quality (and thus potentially a growth) indicator is heavily supported in the literature. Cole (9), Meyers (28), and numerous other investigators have found that citation counts represent a valid criterion of quality and "that straight citation counts are highly correlated with virtually every refined measure of quality" (9, p. 39). Based on the findings of such studies, the decision was made to identify and test six prestige indicators in order to study their roles, if any, in the relationship between the research methods used in a subfield and the growth rate of published research in that subfield.

The literature contains a variety of studies that focus on the relationship between prestige (or eminence) measures and citation data. Bayer and Folger (2) use the rankings established by Cartter in his report, An Assessment of Quality in Graduate Education (6), to study the relationship between institutional quality and citation counts; data for their investigation were generated using Science Citation

Index (38). The Cartter report (6) rankings are also utilized by Knudsen and Vaughan (21) in a study of higher education in sociology. In both of these studies, the authors found significant relationships between the Cartter report (6) rankings and citation data. The Cartter report rankings were utilized in the present study as control variables. Further discussion of this concept is presented in Chapter I.

Several other measures of prestige also are utilized in the present study. One of these is based on listings in biographical publications. Clark (8) used listings in publications such as Who's Who in America as indicators of prestige. In the case of the present study, the publication utilized is American Men of Science (1). Two other prestige control variables are based on the idea that the geographic location of an author's employment and the type of institution at which the author was employed could serve as prestige indicators; Persell (33) proposes the utility of these two variables as prestige measures. For the purpose of the present study, the variable of geographic location consists of the four regions defined by the Bureau of the Census (36), which are northeast, south, north central, and west; in addition, the category other was added to allow for foreign locations. In the case of the control variable that is based on the type of institution at which the author was employed, the four designated categories are academic, state or federal government, industry, and other.

The sixth control variable used in the present study is the gender of the primary author. Considerable research has been done on this variable. Hughes (20) concludes from his study that male scientists are less likely to consider female scientists as worthy of being included in the basic information transfer. Reported extensively in the literature is the effect that gender can have on author ordering in published work; Dash (11) reports that this can be a particular problem for women who are married to their collaborators. In such a case, first authorship may be seen as a favor rather than as a reflection of actual contribution. Reskin (37) has published an excellent review article on this variable.

Summary

The purpose of Chapter II was to describe the population and sample and to provide an explication of the methods and procedures utilized in the present study. The background and development of the instrument is presented, together with the introduction of the control variables, and the data collection and instrument validation procedures.

The instrument was developed using a three stage process. First, the research methods evaluation literature was reviewed in order to identify a consensus set of twenty-nine evaluative criteria. Second, this original set was condensed to twenty items which were submitted for review to a panel of judges. Third, the final nineteen item evaluation

instrument is presented, together with supporting references drawn from the evaluative and geologic literature.

Finally, the instrument was applied in evaluating a sample of 244 research articles. This sample was drawn from a population of research articles in geochemistry and vertebrate paleontology as indexed in the 1965 and 1966 editions of the Bibliography of North American Geology.

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CHAPTER III

DATA ANALYSES AND FINDINGS

This chapter reports the data and basic findings of the present study. In all of the analyses that follow, the programs in the Statistical Package for the Social Sciences (SPSS) (17) were utilized.

Validation of the Instrument

In addition to the content validity procedures that are detailed in Chapter II, a measure of the external validity for the evaluation instrument was required as part of the present study. This process investigated and tested two variables. The first consists of the research methods evaluation score for each item in the sample (ordinal), while the second is composed of the number of citations received by the sample item over a five-year period (interval). Given the necessity to deal with both ordinal and interval data, a nonparametric statistical procedure was used. As a high probability existed of tied scores at each rank, the Kendall tau rank correlation procedure, with its corrections for tied ranks, was selected as an appropriate test (7, pp. 256-260; 8, pp. 296-298; 9, pp. 414-422; 10; 23). This operation yielded a measure of association as well as a test of significance.

Citations are recognized and accepted throughout the literature as valid indicators of research quality (1; 4; 11; 12; 13; 14). Cole concludes, "Straight citation counts are highly correlated with every refined measure of quality," (6, p. 39). Given this recognition and the empirical investigations that have established its validity, citation counts for the sample were correlated with the research methods evaluation score for the identical sample items. The results of this test are seen in Table I below. (Univariate frequency distributions of both variables are presented in Appendix F, Tables XXII and XXIII; a bivariate distribution for these variables is presented in Appendix G, Table XXIV; Appendix D lists each sample item showing (a) document number and (b) the research methods evaluation score and ciataion score for that item.)

TABLE I

KENDALL TAU CORRELATION OF THE EVALUATION SCORES WITH THE CITATION COUNTS FOR COMBINED SUBFIELDS

Coefficient	0.5555
Significance	$p < 0.001$
Cases	244.

The relatively strong Kendall tau correlation coefficient reported in Table I, 0.5555 (with $p<0.001$), reflects the

combined subfields. The results are supportive of the validity of the evaluation instrument for the present study.

While not universally recognized as a problem, it is conjectured in the literature (18) that the different sizes of particular fields or subfields under study could introduce an error if they are combined as part of a citation analysis procedure. Although Cole (6, pp. 24-26) found that this does not constitute a significant problem in the case of physics, there is a legitimate concern for the potential effects of this problem. For this study, therefore, Kendall tau correlation coefficients were also independently computed for each subfield (7, pp. 256-260; 8, 296-298; 9, pp. 414-422; 10; 23), and the results are displayed below in Table II. (Univariate frequency distributions for the research methods evaluation scores and the citations scores for each subfield are presented in Appendix F, Tables XIV-XVII.)

TABLE II

KENDALL TAU CORRELATION OF THE EVALUATION SCORES WITH THE CITATION COUNTS FOR THE INDIVIDUAL SUBFIELDS

	Subfields	
	Vertebrate Paleontology	Geochemistry
Coefficient	0.3781	0.5452
Significance	$p < 0.001$	$p < 0.001$
Cases	122.	122.

As with the combined subfield calculations, the data in Table II are also supportive of the validity of the research methods evaluation instrument as a measure of quality.

Test of the Major Hypothesis

The major hypothesis of this study is that there is a statistically significant relationship between the use of selected research methods criteria in the published literature of a subfield and the growth rate of the published literature of that subfield. As a test of this hypothesis, each of the 244 published research items in the sample was read and scored using the methods evaluation instrument (Appendix D) and procedures described previously.

Since all scoring was carried out by the author of the present study, a general check of the scoring reliability was made by the following procedure. Twenty-six sample items (thirteen from each subfield) were randomly selected and scored a second time. Of the 494 responses (twenty-six sample items multiplied by the nineteen answers on each evaluation form), a total of only eight were scored differently the second time. This represents a consistency rate of 98.5 per cent (see Appendix E), although the retested sample is too small to assess statistical significance. As an additional control on evaluator reliability, the sample items for each subfield were evaluated in an alternating pattern; one item from geochemistry was evaluated, followed by an item from the vertebrate paleontology sample, and so on.

Since all data involved in testing the major hypothesis are treated as ordinal, an ordinally based statistical technique was utilized. The initial test procedure consisted of computing a Kendall tau c correlation coefficient (3, pp. 418-426; 16, pp. 207-208; 20, pp. 348-352) for the research methods evaluation instrument score with the growth rate score. The range of evaluation scores is from eight through nineteen (see Appendix D). The data for this particular test consist of the ranked evaluation scores with no regrouping of data into larger categories. For the purposes of the test, the subfield of vertebrate paleontology was assigned a growth rate score of one (slow), while geochemistry was given the score of two (rapid growth). The results of this initial test of the major hypothesis are presented in Table III. (A univariate distribution of the independent variable is presented in Appendix F, Table XII; a bivariate distribution of the independent and dependent variables is presented in Appendix G, Table XXV.)

TABLE III

KENDALL TAU c CORRELATION OF THE EVALUATION SCORES WITH THE SUBFIELD GROWTH RATE

Coefficient	0.57182
Significance	$p < 0.00001$
Cases	244

As displayed in Table III, the Kendall tau c correlation coefficient for the relationship of the research methods evaluation score with the growth rate of a subject field is 0.57182 (with $p<0.00001$). This clearly supports the major hypothesis.

A Kendall tau b correlation coefficient (with its provisions for ties and a 2x2 table) was computed with the research methods evaluation scores grouped into two categories (3, pp. 418-426; 20, pp. 348-352; 23, pp. 334-336). Each category contains roughly one half of the total combined sample items without regard to individual subfield; the first consists of the low scores, eight through fifteen, while the second contains the higher scoring items, sixteen through nineteen. The results are presented in Table IV. (A bivariate distribution of these two variables is presented in Appendix G, Table XXVI.)

TABLE IV

KENDALL TAU b CORRELATION OF THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE

Coefficient	0.41838
Significance	p<0.00001
Cases	244.

The resulting correlation coefficient of 0.41838 (with $p < 0.00001$) continues to provide support of the major hypothesis.

Analysis of the Control Variables

Further investigation of the major hypothesis was accomplished by identifying and testing the possible roles of six potential extraneous variables. As previously discussed, these six control variables were identified and selected on the basis of a literature search. The three ordinal variables selected are (a) listing of the primary author in American Men of Science (2), (b) ranking of the quality of the primary author's graduate program, using the rankings in the Cartter report (5), and (c) ranking of the effectiveness of the primary author's graduate program, using the rankings in the Cartter report (5). The three nominal variables that are utilized as controls are (d) gender of primary author, (e) geographic location of primary author's employment, and (f) type of institution at which the primary author was employed. All of the selected test variables are potential prestige measures that focus directly on the author of the research. This focus was chosen because it coordinates well in concept with the independent and dependent variables.

Partial correlation (3, pp. 440-442; 16, pp. 225-227; 21, pp. 418-419) is the statistical analysis test that was used to investigate the possible influences of the three ordinal control variables. This procedure is appropriate

since all the data are at the ordinal level. The first step consists of the computation of a zero-order correlation coefficient for the relationship between the research methods evaluation scores and the subfields' growth rates. The results of this computation are presented in Table V. The zero-order correlation is 0.4800 (with $p < 0.00001$). This coefficient differs slightly from that computed from the same data for the Kendall tau c (0.57182) because different algorithms are utilized.

TABLE V

ZERO-ORDER CORRELATION OF THE EVALUATION SCORES WITH THE SUBFIELD GROWTH RATE

Coefficient	0.4800
Significance	$p < 0.00001$
Cases	244

Following the computation of the zero-order relationship (Table V), first-order partial correlation coefficients were computed for the same two variables. However, in the case of the first-order coefficients, the effect of each of the three potential extraneous variables is controlled for, one at a time. The results of these computations are given in Table VI, wherein the data indicate that controlling for the effect of each of the three variables does not substantially

reduce or increase the strength of the original relationship. As a result, the major hypothesis is further supported. (Frequency distributions for the three ordinal control variables are presented in Appendix F, Tables XXVIII-XXX; bivariate distributions of these variables are presented in Appendix G, Tables XXVII-XXIX; trivariate distributions of the independent, dependent, and ordinal control variables are presented in Appendix G, Tables XXXIII-XXXV.)

TABLE VI

FIRST-ORDER PARTIAL CORRELATION FOR THE EVALUATION SCORES WITH THE GROWTH RATE CONTROLLING FOR THE THREE ORDINAL CONTROL VARIABLES

	Coefficient	p	N
Zero-Order Correlation of Evaluation Scores with Growth Rate	0.4800	<0.00001	244
First-Order Partial Correlation of Evaluation Scores with Growth Rate Controlling for Listing in American Men of Science (2)	0.4801	<0.00001	244
First-Order Partial Correlation of Evaluation Scores with Growth Rate Controlling for Rank of Graduate Faculty in Cartter Report (5) of Primary Author	0.4442	<0.00001	80
First-Order Partial Correlation of Evaluation Scores with Growth Rate Controlling for Rank of Graduate Program in Cartter Report (5) of Primary Author	0.4409	<0.00001	86

In addition to the three ordinal control variables, three nominal level variables were also selected for testing. These are gender of primary author, geographic location of primary author's employment, and type of institution at which the primary author was employed. Since partial correlation analysis using ranked data is unsuitable for nominal level data, cross-tabulation with three-way tables was selected as an appropriate statistical procedure. As a first step, a cross-tabulation of the independent (research methods evaluation score) and the dependent (growth rate) variables was computed. In order to achieve a sufficient number of cells with an expected frequency of at least 5 per cent, it was necessary to group the evaluation scores. As explained previously, the first category consists of sample items with scores from eight through fifteen, while the second contains items with evaluation scores from sixteen through nineteen. The results of this first cross-tabulation are presented in Table VII, which includes a significance level of $p < 0.00001$. The test of association that was chosen as appropriate is lambda (asymmetric) (15, pp. 249-255; 16, pp. 195-199; 19, pp. 78-82). Its application results in a coefficient of 0.41803. These results clearly support the major hypothesis.

The first nominal variable that was tested as a control is the geographic location of the primary author's employment.

TABLE VII

LAMBDA (ASYMMETRIC) CORRELATION OF THE GROUPED EVALUATION SCORES WITH THE SUBFIELD GROWTH RATE

Coefficient	0.41803
Significance	$p < 0.00001$
Cases	244

The variable is subdivided into the five areas of north, north-central, south, and west. Each of these was tested and controlled for independently of the others. The resulting data analysis is presented in Table VIII. (A univariate distribution of this control variable is presented in Appendix F, Table XXI; a bivariate distribution of the control variable and the dependent variable is presented in Appendix G, Table XXX; a trivariate distribution of the independent, dependent, and control variables is presented in Appendix G, Table XXXVI.) In the case of those values that resulted in cell frequencies of less than 5 per cent, no significance lambda (asymmetric) computations were carried out. As Table VIII data indicate, the geographic location of the primary author's employment exerts some influence on the relationship of the independent and dependent variable, but in no case does controlling for the effects of geography cause the major relationship to disappear. As a result, when taken

TABLE VIII

LAMBDA (ASYMMETRIC) SCORES FOR THE GROUPED EVALUATION SCORES WITH THE GROWTH RATE CONTROLLING FOR EFFECTS OF THE GEOGRAPHIC LOCATION OF EMPLOYMENT OF PRIMARY AUTHOR

	Lambda (Asymmetric) Score	p	N
Grouped Evaluation Scores with Growth Rate	0.41803	<0.00001	244
Grouped Evaluation Scores with Growth Rate Controlling for Location Category North	0.20833	<0.0338	56
Grouped Evaluation Scores with Growth Rate Controlling for Location Category South	0.25000	<0.0838	37
Grouped Evaluation Scores with Growth Rate Controlling for Location Category North Central	0.18750	<0.0043	49
Grouped Evaluation Scores with Growth Rate Controlling for Location Category West	0.42857	<0.00001	70
Grouped Evaluation Scores with Growth Rate Controlling for Location Category Other	0.25000	<0.0441	25
Grouped Evaluation Scores with Growth Rate Controlling for Location Category Unknown	not computed	not computed	7

together with the other test results the major hypothesis continued to be supported.

The second nominal variable tested as a control is the gender of the primary author. The statistical analysis selected as appropriate is the same as that employed for geographic location. As shown in Table IX data, the very small number of women in the sample invalidates an analysis for this category. However, when the category male is controlled for, the resulting lambda (asymmetric) of 0.39080 (with $p < 0.00001$) is not substantially different from that displayed by the uncontrolled major relationship. As a result, the major hypothesis continues to be supported. (A univariate distribution for this variable is available in Appendix F, Table XXII; a bivariate distribution of the dependent variable and the control variable is presented in Appendix G, Table XXXI; a trivariate distribution of the dependent, independent, and control variables is presented in Appendix G, Table XXXVII.)

Another nominal variable controlled for is the type of institution at which the primary author was employed. This variable was subdivided into the four categories of academic, federal or state government, industry, and other. However, the heavy concentration of items in the academic category resulted in expected cell frequencies of less than 5 per cent for the remaining values. As a result, the chi-square test of significance and the lambda (asymmetric) test of

TABLE IX

LAMBDA (ASYMMETRIC) SCORES FOR THE GROUPED EVALUATION SCORES WITH THE GROWTH RATE CONTROLLING FOR EFFECTS OF GENDER OF PRIMARY AUTHOR

	Lambda (Asymmetric) Score	p	N
Grouped Evaluation Scores with Growth Rate	0.41803	<0.00001	244
Grouped Evaluation Scores with Growth Rate Controlling for Gender Category Male	0.39080	<0.00001	201
Grouped Evaluation Scores with Growth Rate Controlling for Gender Category Female	not computed	not computed	10
Grouped Evaluation Scores with Growth Rate Controlling for Gender Category Unknown	not computed	not computed	33

association were computed only for the academic category. The result of this analysis is a lambda (asymmetric) coefficient of 0.34722 (with $p < 0.00001$) when the effect of type of employment is controlled for in the relationship between the research method valuation score and the subfields' growth rates (Table X). As with the other potential extraneous variables, the original relationship is not substantially changed. Thus, the major hypothesis is supported. (A univariate frequency distribution for this variable is displayed in Appendix F, Table XXIII; a bivariate distribution of the dependent variable and the control variable is presented in Appendix G, Table XXXII; a trivariate distribution of the dependent, independent, and control variables is presented in Appendix G, Table XXXIII.)

TABLE X

LAMBDA (ASYMMETRIC) SCORES FOR THE GROUPED EVALUATION SCORES WITH THE GROWTH RATE CONTROLLING FOR EFFECTS OF TYPE OF INSTITUTION EMPLOYING PRIMARY AUTHOR

	Lambda (Asymmetric) Score	P	N
Grouped Evaluation Scores with Growth Rates	0.41803	<0.00001	244
Grouped Evaluation Scores with Growth Rate Controlling for Employment Category Academic	0.34722	<0.00001	162

TABLE X--Continued

	Lambda (Asymmetric) Score	p	N
Grouped Evaluation Scores with Growth Rate Controlling for Employment Category Federal or State Government	not computed	not computed	36
Grouped Evaluation Scores with Growth Rate Controlling for Employment Category Industry	not computed	not computed	26
Grouped Evaluation Scores with Growth Rate Controlling for Employment Category Other	not computed	not computed	7
Grouped Evaluation Scores with Growth Rate Controlling for Employment Category Unknown	not computed	not computed	8

SUMMARY

The purpose of Chapter III was to provide the data analyses and findings of the present study. The validity of the instrument was assessed and the major hypothesis was tested. In addition, each of the control variables was analyzed.

In assessing the validity of the instrument a Kendall tau correlation coefficient of 0.5555 ($p < 0.001$) was obtained for the relationship between the research methods evaluation scores of the sample of 244 research items and the citation

counts for the same items. When the two subfields were analyzed separately (with 122 research items in each subfield), a Kendall tau coefficient of 0.5452 ($p < 0.001$) was obtained for geochemistry, while a Kendall tau coefficient of 0.3781 ($p < 0.001$) was obtained for vertebrate paleontology. Each of the three tests is supportive of the validity of the evaluation instrument as an indicator of research quality.

The major hypothesis was tested twice. First the Kendall tau c procedure was utilized in which the ungrouped evaluation scores were correlated with the rate of subfield growth, resulting in a coefficient of 0.57182 ($p < 0.00001$). Second, the Kendall tau b procedure was used in which the evaluation scores were grouped into two categories, eight through fifteen and sixteen through nineteen. The resulting coefficient was 0.41838 ($p < 0.00001$). Each test supported the major hypothesis.

The three ordinal control variables were tested utilizing a partial-correlation technique. The zero-order coefficient for the correlation of the research methods evaluation scores and the rate of growth for the two subfields was 0.4800 ($p < 0.00001$). When first-order partial coefficients were computed, controlling for the effects of each control variable individually, the following results were obtained: for the listing of the primary author in American Men of Science, 0.4801 ($p < 0.00001$); for the rank of the primary author's graduate faculty in the Cartter Report, 0.4442 ($p < 0.00001$);

and for the rank of the primary author's graduate program in the Cartter Report, 0.4409 ($p < 0.00001$). The results of these tests indicated that controlling for the effect of each of the three variables did not substantially reduce or increase the strength of the original relationship.

The three nominal variables were tested utilizing lambda (asymmetric) as a measure of association and chi-square as a test of significance. As a first step a lambda (asymmetric) score for the relationship of the grouped research methods evaluation scores with the subject subfield growth rate was computed as 0.41803 ($p < 0.00001$). Each category of the three control variables was controlled for and tested independently of the others. First, the geographic location of the primary author's employment was computed with the following results for the controlled relationship: for the category north, 0.20833 ($p < 0.0338$); for the category south, 0.25000 ($p < 0.0838$); for the category north central, 0.18750 ($p < 0.0043$); for the category west, 0.42857 ($p < 0.00001$); for the category other, 0.25000 ($p < 0.0441$); and for the category unknown no statistics were computed due to inadequate cell frequencies. Second, the gender of the primary author was computed with the following results for the controlled relationship: for the category male, 0.39080 ($p < 0.00001$); and for the categories female and unknown no statistics were computed due to inadequate cell frequencies. Third, the type of institution employing the primary author was computed with

the following results for the controlled relationship: for the category academic, 0.34722 ($p < 0.00001$); for the categories federal or state government, industry, other, and unknown, statistics were not computed due to inadequate cell frequencies. For all three nominal control variables their introduction into the major relationship did not substantially change that relationship, thus continuing to support the major hypothesis.

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CHAPTER IV

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the relationship between the research methods that are reported in the published research of a selected subfield and the growth rate of the published literature of that subfield. The independent and dependent variables (research methods and literature growth) have each received considerable attention in the literature. However, aside from theoretical considerations of knowledge growth and its general relationship to research methods and design, very little empirical work appears to have been done on the functional relationship of these two variables. The present study endeavors to help fill this gap by testing the central hypothesis that a correlation exists between characteristics of the research methods used in a subject subfield and the growth of the published literature in that subfield. In addition, six control variables were evaluated for their potential influence in this relationship.

Each of the variables used in the study was operationally defined. The independent variable (research methods) was operationalized as an ordinal level score, obtained from a

nineteen-item research methods instrument. The dependent variable (literature growth) was defined in terms of growth rates of the published literature in two geology subfields, geochemistry and vertebrate paleontology in 1965-1966. The first subfield manifested a rapid growth rate while the second showed a much slower rate, according to Menard's tabulations for these years. The control variables utilized were listing of the primary author in American Men of Science (1), ranking of the quality of the primary author's graduate faculty in the Cartter report (3), ranking of the quality of the effectiveness of the primary author's graduate program in the Cartter report (3), the geographic location of the primary author's employment, the primary author's gender, and the type of institution at which the primary author was employed.

The present study attempts to investigate the linkage between the theoretical considerations of the forces that direct knowledge growth and the more operational techniques of research methods evaluation. In doing so, additional work was carried out in an investigation of these first two phenomena and the commonly accepted bibliometric technique of analyzing citations as a means of identifying significant or quality research.

Methods and Procedures

This study used a non-experimental research design. A research methods evaluation instrument was developed

specifically for this study; it is based on a review of the research methods evaluation literature, and it is composed of nineteen evaluative criteria. Validation of the instrument took two forms. First, content validity was based on an initial search of the research methods evaluation literature and a panel review of five judges. Second, criterion external validity was assessed by correlating the evaluation instrument scores with a known and accepted indicator of research quality. This indicator consists of citation counts for the published sample research items. Extensive support is found throughout the literature for this approach. The Kendall tau rank correlation procedure was identified as an appropriate statistical test, and a coefficient of 0.5555 (with $p < 0.001$) was obtained.

The literature review revealed some concern over the validity of combining different sized subject fields in a single citation analysis procedure. This concern was based on an assumption that the larger field might bias the results; accordingly individual Kendall tau procedures were undertaken in order to establish the relationship of the separate subfields and the citation count to that field's published research sample. For the subfield of geochemistry, a Kendall tau of .5452 (with $p < 0.001$) was obtained; in the subfield of vertebrate paleontology, a coefficient of .3781 (with $p < 0.001$) was obtained. Although there is some drop in the coefficient's strength for vertebrate paleontology,

it remains sufficiently strong to provide support for the external validity of the instrument.

Analyses of Data

The major hypothesis of the study states that a correlation exists between characteristics of the research methods used in a subject subfield and the growth of the published literature of that subfield. To test this hypothesis, a sample composed of 244 published research items (122 from each subfield) was randomly drawn from the 1965 and 1966 volumes of the Bibliography of North American Geology for the purpose of testing the hypothesis. The sample was identified and selected utilizing subject headings previously identified as stable by Menard. Each research item in the sample research was individually evaluated using the research methods evaluation instrument described previously. The resulting evaluation scores were correlated with the two established values for the dependent variable (fast and slow growth rates) using the Kendall tau c procedure. A rank coefficient of 0.57182 (with $p < 0.0001$) was obtained. This result is supportive of the major hypothesis.

Control Variables

In order to investigate further the relationship affirmed by the major hypothesis, six control variables were utilized. The potential influence of each control variable was evaluated.

Since the first three selected control variables are measurable at the ordinal level, partial correlation was chosen as an appropriate statistical test. Utilizing a zero-order coefficient for the major uncontrolled relationship of the research methods evaluation scores and growth rates, first-order partial coefficients were computed by controlling for the effects of each prestige variable in turn. The basic zero-order coefficient is 0.4800 (with $p < 0.00001$). The first order partials for this same relationship, holding constant the effects of the relevant control variables, are the listing of the primary author in American Men of Science (1) is 0.4801 (with $p < 0.00001$), the rank of the primary author's graduate faculties in the Cartter report (3) is 0.4442 (with $p < 0.00001$), the ranked effectiveness of the primary author's graduate program in the Cartter report (3) is 0.4409 (with $p < 0.00001$). These results do not reflect any appreciable change in the initial relationship of the research methods evaluation score and growth rate. The findings appear to support the major hypothesis.

Since the remaining three control variables are measurable at a nominal level, partial correlation is not an appropriate statistical test of their roles in the major relationship under study. Instead, a cross-tabulation technique was utilized with chi-square as a significance test and lambda (asymmetrical) as a measure of association. In order to achieve a large number of cells with an expected frequency of

at least 5 per cent of the sample, the research methods evaluation scores were grouped into two categories. When these grouped scores were tested with the growth rate score, the result was a lambda (asymmetrical) score of 0.41803, with a chi-square significance measure of $p < 0.00001$. The three nominal level control variables tested were geographic location of primary author's employment, gender of primary author, and type of institution at which the primary author was employed. When the effects of each of these variables was controlled for individually, the major hypothesis continued to be supported.

Summary of Findings

In overall summary, following are the principal findings of this study.

1. The major hypothesis is supported by the results of the investigation. The research methods evaluation scores were found to correlate significantly and positively with the rates of growth of the published literature of the subject subfields studied. A Kendall tau c rank coefficient of .57182 (with $p < 0.00001$) was obtained using ungrouped evaluation scores; using grouped research methods evaluation scores, a Kendall tau b coefficient of 0.41838 (with $p < 0.00001$) was obtained;

2. Both content and external validity were assessed for the research methods evaluation instrument. With regard to content validity, a search of the research methods evaluation

literature was made in order to identify and isolate a potential set of research methods criteria, and a panel of five judges was then utilized in reviewing and selecting a final set of criteria. External validity was assessed by correlating the research methods evaluation scores and citation counts for the sample research items. The result was a Kendall tau coefficient of 0.5555 (with $p < 0.001$) for the combined subfields. When the two subfields were evaluated independently, similar results were obtained. In the case of geochemistry, a Kendall tau coefficient of 0.5452 (with $p < 0.001$) was obtained; a Kendall tau coefficient of 0.3781 (with $p < 0.001$) was obtained for vertebrate paleontology. In all three tests, the resulting coefficients provide support for the external validation of the research methods evaluation instrument;

3. Six control variables were tested. These include listing of the primary authors in the 1965 edition of American Men of Science (1), ranking of the quality of the primary authors' graduate faculties in the Cartter report (3), ranking of the quality of the effectiveness of the primary authors' graduate programs in the Cartter report (3), geographic location of the primary authors' employment, gender of the primary authors, and type of institution by which the primary authors were employed. None of the six control variables was found to alter a materially extraneous role in the basic relationship expressed by the major hypothesis.

Generalization of Findings

With regard to the results of the present investigation, no formal generalizations can be made beyond the two subfields sampled and studies, since these subfields were not randomly drawn from a broader population. Restrictions are also imposed by the years for which the subfields were sampled and by the limited size of the sample of research items drawn for these years. Therefore, generalization is feasible only to the extent to which the sample research items under the selected subject headings in the two subfields as indexed in the Bibliography of North American Geology for 1965-1966 may be regarded as typical of research indexed under other relevant subject headings for the two subject subfields.

Implications

While keeping in mind the preceding restrictions, two implications of possible special interest may be noted for the present study. First, the finding for the field of geology that a fast-growth subfield (geochemistry) appears to employ certain research methods to a greater extent than a related slow-growth subfield (vertebrate paleontology) may be suggestive of a pattern that may also hold in other fields of science. Should this prove to be so (as an outcome of further investigations in this regard), there is an implication that the kinds of research methods used might be considered as one explanation for the differing rates of growth

in different subject subfields. Second, given the extreme problems facing collection development managers today, such a pattern could be of significant worth in predicting the possible relative growth of particular subject subfields.

Relation of Findings to Other Studies

That some type of relationship exists between research methods and rate of subject subfield growth is generally assumed in the literature. However, only a very limited amount of actual research has been undertaken beyond theoretical formulations. Kuhn (6), for example, concentrates his efforts on the phenomena of knowledge growth in terms of broad global cycles on methodological approaches; he does not investigate in detail the precise research methods employed in each cycle. Similarly, but from a different philosophical orientation, Lakatos (7) and Popper (11) consider knowledge growth phenomena at a broad theoretical level; unlike Kuhn, however, they approach the functional level by investigating the concept of a research tradition based on hypothesis falsifiability methods as a means of explaining the mechanism of scientific knowledge growth and progress. Platt (10), carrying forward the concepts of falsifiability and crucial experiment, hypothesizes that those fields which consistently adopt these research methods criteria as part of their research tradition will grow and progress faster than those fields which do not; as with Kuhn, Lakatos, and

Popper, however, he confines himself to a theoretical consideration of the problem.

The investigators of research method evaluation, such as Gephart (5) and Persell (9) consider various evaluative criteria that could serve as indicators of the methodological quality of research. However, they do not consider the methodological quality from the standpoint of knowledge growth. While their work in the identification, isolation, and use of these criterion is significant, their attention is generally limited to these particular facets.

In the area of the identification and testing of bibliometric factors, especially citations, that are involved in the explication of knowledge growth, the works of Bayer and Folger (2), Cole (4), Meyers (8), and Zuckerman (12) stand out. They have established the utility not only of citations but of several other measures of eminence and prestige as valid indicators of research quality. However, they remain at a level of detail one step removed from the actual consideration of the research methods reported in an investigation; they prefer to work with secondary data on the quality of given items. An intended contribution of the present study is that it take this next step by attempting to link research methods and growth rate at the functional level of the research item itself.

Recommendations for Further Study

In conclusion, recommendations for further study may be noted as follows:

1. The problem of research methods evaluation and the criteria for evaluation need to receive increased attention and to be investigated in additional subject fields. While several studies in this regard have been undertaken in the fields of education and the social sciences, other subject fields have yet to be examined;

2. The role of research methods as a factor in the growth of subject subfields needs to be considered further for geology as well as other fields, and both descriptive and causal models should be developed;

3. Incidental to the preceeding recommendations, further studies should be undertaken to identify additional potential extraneous variables beyond those tested in this study, and to consider their possible roles in the relationship of research methods and subject subfield growth;

4. Finally, the effort should be made to derive descriptive and causal models for particular fields and subfields from more general and more quantitative formulations of the different factors relating to the patterns of subject literature growth.

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APPENDIX A

INITIAL CONSENSUS SET OF INDICATORS

____ 1. Is the purpose of the inquiry stated?

____ 2. Is there a review of the literature?

____ 3. Does the review of the literature have a theoretical component?

____ 4. Does the review of the literature have a substantive component?

____ 5. Does the review of the literature have a methodological component?

____ 6. Does the review of the literature have a critical component?

____ 7. Are the variables explicitly identified?

____ 8. Are the variables implicitly identified?

____ 9. Is at least one hypothesis stated explicitly?

____10. Is at least one question stated explicitly?

____11. Is one (only) hypothesis per phenomena studied stated explicitly and/or implicitly?

____12. Is more than one hypothesis stated explicitly and/or implicitly to explain the same phenomena?

____13. Are rival explanations for a dependent phenomena eliminated through testing within the context of the inquiry?

____14. Are rival explanations for a dependent phenomena eliminated on the basis of assumptions based on other studies?

____15. Are rival explanations for a dependent phenomena explicitly recognized but with no attempt to eliminate them within the context of the inquiry?

____16. Is the population explicitly identified?

____17. Is the sample explicitly identified?

____18. Was the sample selected randomly?

____19. Was the sample selected using purposive sampling?

____20. Is a hypothesized relationship tested empirically?

____21. Is a question answered empirically?

____22. Are mediating variables identified as such?

____23. Are controls for mediating variables, identified but not included in the inquiry, explicitly stated?

____24. Are data analyzed quantitatively, but not statistically?

____25. Are data analyzed statistically?

____26. Are all of the stated hypotheses and/or questions accounted for in the results?

____27. Are the stated conclusions drawn from the findings of the inquiry?

____28. If the findings require a change in the theoretical foundations of the inquiry, is it explicitly discussed?

____29. Are suggestions for additional inquiry stated?

APPENDIX B

RESEARCH QUALITY MEASUREMENT INSTRUMENT

VALIDATION OPINION VERSION

1. Is the purpose of the inquiry stated?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

2. Is there a review of the literature?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

3. Does the review of the literature have a theoretical component?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

4. Does the review of the literature have a substantive component?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

5. Does the review of the literature have a methodological component?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

6. Does the review of the literature have a critical component?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

7. Are the variables explicitly identified?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

8. Is at least one hypothesis and/or question stated explicitly?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

9. Is more than one hypothesis stated explicitly and/or implicitly to explain the same phenomena?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

10. Are rival explanations for a dependent phenomena eliminated through testing within the context of the inquiry?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

11. Is the population explicitly identified?
   ____Yes, the item is appropriate.
   ____No, the item is not appropriate.
   Comments:

12. Is the sample explicitly identified?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

13. Was the sample selected randomly?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

14. Is a hypothesized relationship or a question tested through direct observation?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

15. Are mediating variables both identified as such and controlled for within the context of the inquiry?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

16. Are data analyzed using statistical methodology?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

17. Are all of the stated hypotheses and/or questions accounted for in the results?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

18. Are all the stated conclusions drawn from the findings of the inquiry?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

19. If the findings require a change in the theoretical foundations of the inquiry, is it explicitly discussed?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

20. Are suggestions for additional inquiry stated?
    ____Yes, the item is appropriate.
    ____No, the item is not appropriate.
    Comments:

General Comments

APPENDIX C

FINAL INDICATOR SCORE SHEET

DOCUMENT NUMBER	TOTAL
XXXXXXXXXXX	XXXXXXXXXXX

____ 1. IS THE PURPOSE OF THE INQUIRY INDICATED?

____ 2. DOES THE REVIEW OF THE LITERATURE HAVE A THEORETICAL COMPONENT?

____ 3. DOES THE REVIEW OF THE LITERATURE HAVE A CRITICAL COMPONENT?

____ 4. IS THE SAMPLE IDENTIFIED WITH PRECISION?

____ 5. IS THE RATIONALE OR METHOD OF SAMPLE SELECTION EXPLAINED?

____ 6. ARE THE INDIVIDUAL VARIABLES DESCRIBED NUMERICALLY?

____ 7. ARE POSSIBLE MEDIATING VARIABLES NOTED?

____ 8. ARE THE DATA ANALYZED USING STATISTICAL METHODOLOGY?

____ 9. ARE THE DATA ON DIFFERENT VARIABLES RELATED TO EACH OTHER NUMERICALLY?

____10. IS THERE AT LEAST ONE EXPLICIT OR IMPLICIT HYPOTHESIS OR QUESTION?

____11. IS AT LEAST ONE HYPOTHESIS-QUESTION TESTED?

____12. ARE MULTIPLE HYPOTHESES PROPOSED TO EXPLAIN THE SAME PHENOMENA?

____13. ARE MULTIPLE HYPOTHESES TESTED TO EXPLAIN A SINGLE PHENOMENA?

____14. ARE ASSUMPTIONS IDENTIFIED AS SUCH?

____15. IS THE PROCEDURE(S) USED TO INVESTIGATE THE HYPOTHESIS(S) DESCRIBED WITH PRECISION?

____16. ARE LIMITATIONS OF THE INQUIRY NOTED?

____17. ARE THE CONCLUSIONS BASED ON THE FINDINGS OF THE INQUIRY?

____18. ARE THE FINDINGS' POSSIBLE IMPACTS ON THEORY ACKNOWLEDGED?

____19. ARE RECOMMENDATIONS FOR ADDITIONAL INQUIRY STATED?

APPENDIX D

SAMPLE ARTICLES WITH EVALUATION AND CITATION SCORES

This appendix includes the 244 sample items. Each entry includes: (1) bibliographic citation; (2) the evaluation score as well as a listing of the individual indicators that received a score of one; and (3) the citation score for the item.

Vertebrate Paleontology

1. Alf, Raymond M., "Mammal Trackways from the Barstow Formation, California," Southern California Academy of Science Bulletin, LXV (1966), 258-264.

   ES = 11 (1, 2, 5, 6, 8, 9, 10, 11, 12, 15, 17); CS = 0.

2. Allison, Ira S., "Fossil Lake, Oregon," Oregon State Studies in Geology, (no. 9, 1966), 1-48.

   ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 2.

3. Arata, Andrew A., "A Tertiary Proboscidian from Louisiana," Tulane Studies in Geology, IV (no. 2, 1966), 73-74.

   ES = 11 (1, 2, 4, 5, 6, 9, 10, 11, 15, 17, 18); CS = 0.

4. Arata, Andrew A., "Fossil Ursus Reported as Early Man in Louisiana," Tulane Studies in Geology, IV (no. 2, 1966), 75-77.

   ES = 13 (1, 2, 4, 5, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 0.

5. Auffenberg, Walter, "A New Fossil Tortoise from the Texas Miocene, with Remarks on the Probable Geologic History of Tortoises in Eastern U.S.," Pearce-Sellards Series, Texas Memorial Museum, XIII (no. 3, 1964), 1-11.

   ES = 16 (1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18, 19); CS = 0.

6. Auffenberg, Walter, "A New Species of Pliocene Tortoise Genus Geochelone from Florida," Journal of Paleontology, XL (no. 4, 1966), 877-882.

   ES = 17 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 1.

7. Aveleyra, Arroyo, "The Pleistocene Carved Bone from Tequixquiac, Mexico," American Antiquity, XXX (no. 3, 1965), 261-277.

   ES = 14 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 17, 18, 19); CS = 0.

8. Baird, Donald, "Footprints from the Cutler Formation," U.S. Geological Survey Professional Paper (no. 503-C, 1965), C47-C50.

   ES = 16 (1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 0.

9. Baird, Donald, "Rare Marine Reptiles from the Crataceous of New Jersey," Journal of Paleontology, XL (no. 5, 1966), 1211-1215.

   ES = 14 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 17, 18, 19); CS = 0.

10. Black, Craig C., "Paleontology and Geology of the Badwater Creek Area, Central Wyoming," Annals of the Carnegie Museum, XXXVIII (no. 13, 1966), 297-307.

    ES = 9 (1, 2, 3, 5, 10, 11, 17, 18, 19); CS = 0.

11. Black, Craig C., "A Review of Late Eocene Mammalian Faunas from North America," American Journal of Science, CCLXIV (no. 5, 1966), 321-349.

    ES = 17 (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 1.

12. Borden, Charles E., "Radiocarbon and Glacial Dating of the Lower Fraser Canyon Archaeological Sequence," International Conference on Radiocarbon and Tritium Dating, 6th 1965 (1966), 165-178.

ES = 14 (1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18); CS = 0.

13. Brophy, John A., "A Possible Bison (Superbison) Crassicornis of Mid-Hypsithermal Age from Mercer County, North Dakota," North Dakota Academy of Science Proceedings, 1965, XIX (1966), 214-223.

ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 2.

14. Buettner-Janusch, John, "Molecules and Monkeys," Science, CXLVII (no. 3660, 1965), 836-842.

ES = 17 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 26.

15. Butler, B. Robert, "An Early Man Site at Big Camas Prairie, South-Central Idaho," Tebiwa, VI (no. 1, 1963), 22-33.

ES = 14 (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 15, 16, 17, 18); CS = 0.

16. Butler, B. Robert, "Further Notes on the Burials and the Physical Stratigraphy of the Congdon Site," Tebiwa, VI (no. 2, 1963), 16-32.

ES = 14 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, 17, 19); CS = 0.

17. Camp, C. L., "Late Jurassic Ichthyosaur from Coastal Oregon," Journal of Paleontology, XL (no. 1, 1966), 204-205.

ES = 13 (1, 2, 3, 4, 6, 7, 10, 11, 12, 13, 15, 17, 11); CS = 0.

18. Carroll, Robert, "Microsaurs from the Westphalian B of Joggins, Nova Scotia," Proceedings of the Linnean Society of London, CLXXVII (no. 1, 1966), 63-97.

ES = 15 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 2.

19. Clark, John, "Status of the Generic Names Metacodon and Geolabis (insectivore)," Journal of Paleontology, XL (no. 5, 1966), 1248-1251.

ES = 15 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 1.

20. Cleland, Charles E., "Barren Ground Caribou (Rangifer Arcticus) from an Early Man Site in Southeastern Michigan," American Antiquity, XXX (no. 3, 1965), 350-351.

ES = 13 (1, 2, 4, 5, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

21. Colbert, Edwin H., "A Gliding Reptile from the Triassic of New Jersey," American Museum Novitates, (no. 2246, 1966), 1-23.

ES = 14 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 17, 18, 19); CS = 0.

22. Colbert, Edwin H., "A Phytosaur from North Bergen, New Jersey," American Museum Novitates (no. 2230, 1965), 1-25.

ES = 15 (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

23. Cuffey, Roger J., "A Microtine Rodent and Associated Gastropods from the Upper Pleistocene of Southwestern Indiana," Journal of Paleontology, XXXVIII (1964), 1109-1111.

ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 1.

24. Dalquest, Walter W., "A New Mammalian Local Fauna from the Lower Pliocene of Texas," Kansas Academy of Science Transactions, XLIX (no. 1, 1966), 79-87.

ES = 12 (1, 2, 3, 4, 5, 6, 9, 10, 11, 15, 17, 18); CS = 0.

25. Dalquest, Walter W., "A New Pleistocene Formation and Local Fauna from Hardeman County, Texas," Journal of Paleontology, XXXIX (no. 1, 1965), 63-79.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 4.

26. Dalquest, Walter W., "The Pleistocene Horse Equus Conoersidens," American Midland Naturalist, LXXIV (no. 2, 1965), 408-417.

ES = 13 (1, 2, 4, 5, 6, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

27. Dawson, Mary R., "Additional Late Eocene Rodents (mammalia) from the Vinta Basin, Utah," Annals of the Carnegie Museum, XXXVIII (no. 4, 1966), 97-114.

ES = 14 (1, 2, 3, 4, 6, 9, 10, 11, 12, 13, 15, 17, 18, 19); CS = 0.

28. Dawson, Mary R., "Oreolagus and Other lagomorpha (mammalia) from the Miocene of Colorado, Wyoming, and Oregon," Colorado University Studies: Series in the Earth Sciences (no. 1, 1965), 1-36.

ES = 15 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 0.

29. Dorr, John A., Jr., "Wind-Polished Stones--Two Similar Sites," Michigan Academy of Science, Arts, and Letters Papers, 1965, LI (1965), 265-273.

ES = 8 (1, 2, 3, 9, 10, 11, 17, 18); CS = 16.

30. Eaton, Theodore H., Jr., "A New Wyoming Phytosaur," University of Kansas Paleontological Contributions, II (1965), 1-6.

ES = 14 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 0.

31. Eddleman, Charles D., "Margay from the Post-Wisconsin of Southeastern Texas," Texas Journal of Science, XVIII (no. 4, 1966), 378-385.

ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

32. Estes, Richard, "Notes on Some Paleocene Lizards," Copeia, 1965 (no. 1, 1965), 104-106.

ES = 16 (1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 0.

33. Etheridge, Richard, "Pleistocene Lizards from New Providence," Quarterly Journal of Florida Academy of Science, XXVIII (1965), 349-358.

ES = 14 (1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 15, 17, 18); CS = 0.

34. Flannery, Kent V., "The Postglacial Readaption as Viewed from Mesoamerica," American Antiquity, XXXI (no. 6, 1966), 800-805.

ES = 15 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 15, 17, 18, 19), CS = 1.

35. Galbreath, Edwin C., "A Dire Wolf Skeleton and Powder Mill Creek Cave, Missouri," Illinois Academy of Science Transactions, LVII (no. 4, 1964), 224-242.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 2.

36. Galbreath, Edwin C., "A Record of Democricetodan (Order Rodentia) from the Late Tertiary of Northeastern Colorado," Illinois Academy of Science Transactions, LIX (no. 3, 1966), 212-213.

ES = 11 (1, 4, 6, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

37. Green, Morton, "Significance of Rangifer in the Herrick Formation of South Dakota," South Dakota Academy of Science Proceedings, XLIV (1965), 48-51.

38. Guilday, John E., "Armadillo Remains from Tennessee and West Virginia Caves," National Speleological Society Bulletin, XXVIII (1966), 183-184.

ES = 8 (1, 2, 4, 9, 10, 11, 17, 18); CS = 0.

39. Guilday, John E., "Rangifer Antler from an Ohio Bog," Journal of Mammalogy, XLVII (no. 2, 1966), 325-326.

ES = 12 (1, 2, 4, 5, 6, 8, 9, 10, 11, 15, 17, 18); CS = 0.

40. Guthrie, Russell D., "Pelage of Fossil Bison: A New Osteological Index," Journal of Mammalogy, XLVII (no. 4, 1966); 725-727.

ES = 9 (1, 2, 8, 9, 10, 11, 15, 17, 18); CS = 0.

41. Guthrie, Russell D., "The Extinct Wapiti of Alaska and Yukon Territory," Canadian Journal of Zoology, XLIV (no. 1, 1966), 47-57.

ES = 13 (1, 2, 3, 4, 5, 7, 10, 11, 12, 15, 17, 18); CS = 1.

42. Guthrie, Russell D., "Variability in Characters Undergoing Rapid Evolution, An Analysis of Microtus Molars," Evolution, XIX (no. 2, 1965), 214-233.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19); CS = 8.

43. Harksen, J. C., "Pteranodon Sternbergi, a New Fossil Pterodoctyl from the Niobrara Cretaceous of Kansas," Proceedings of the South Dakota Academy of Science, XLV (1966), 74-77.

ES = 11 (1, 2, 4, 5, 7, 9, 10, 11, 14, 17, 18); CS = 0.

44. Hawksley, Oscar, "Short-Faced Bear (Arclodus) Fossils from Ozark Caves," National Speleological Society Bulletin, XXVII (1965), 77-92.

ES = 15 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 0.

45. Haynes, C. Vance, Jr., "Prehistoric Springs and Geochronology of the Clovis Site, New Mexico," American Antiquity, XXXI (no. 6, 1966), 812-821.

ES = 12 (1, 2, 3, 4, 5, 8, 9, 10, 11, 15, 17, 18); CS = 1.

46. Holman, J. Alan, "Fossil Snakes from the Valentine Formation of Nebraska," Copeia (1964), 631-637.

ES = 14 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

47. Hibbard, Claude W., "Fossils from the Seymour Formation of Knox and Baylor Counties, Texas, and Their Bearing on the Late Kansan Climate of That Region," Michigan University Museum of Paleontology Contributions, XXI (no. 1, 1966), 1-66.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 2.

48. Holman, J. Alan, "A Late Pleistocene Herpetofauna from Missouri," Illinois Academy of Science Transactions, LVIII (no. 3, 1965), 190-194.

ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

49. Holman, J. Alan, "The Pleistocene Herpetofauna of Miller's Cave, Texas," Texas Journal of Science, XVIII (1966), 372-377.

ES = 12 (1, 2, 4, 5, 8, 10, 11, 12, 13, 15, 17, 18); CS = 0.

50. Holman, J. Alan, "A Small Pleistocene Herpetofauna from Houston, Texas," Texas Journal of Science, XVII (no. 4, 1965), 418-423.

ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 0.

51. Holman, J. Alan, "Fossil Snakes from the Valentine Formation of Nebraska," Copeia (no. 4, 1964), 631-637.

ES = 14 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

52. Holman, J. Alan, "Pleistocene Amphibians and Reptiles from Texas," Herpetologica, XX (no. 2, 1964), 73-83.

ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18, 19); CS = 3.

53. Holman, J. Alan, "Some Pleistocene Turtles from Illinois," Illinois Academy of Science Transactions, LIX (no. 3, 1966), 214-216.

ES = 12 (1, 2, 3, 4, 5, 10, 11, 12, 13, 15, 17, 18); CS = 0.

54. Hopkins, M. L., "Remarks on a Notched Fossil Bison Ischium," Tewiba, IV (no. 2, 1961), 10-18.

55. Howe, John A., "The Oligocene rodent Ischyromys in Nebraska," Journal of Paleontology, XL (no. 5, 1966), 1200-1210.

ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

56. Hunter, H. A., "Odontoma in a Northern Mammoth," Palaeontology, VII (pt. 4, 1964), 674-681.

ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 15, 16, 17, 18, 19); CS = 0.

57. Hutchinson, John H., "Notes on Some Upper Miocene Shrews from Oregon," Oregon University Museum of Natural History Bulletin, II (1966), 1-23.

ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 0.

58. Jelinek, Arthur J., "An Artifact of Possible Wisconsin Age," American Antiquity, XXXI (no. 3, 1966), 434-435.

ES = 8 (1, 5, 6, 9, 10, 11, 15, 17); CS = 0.

59. Jepsen, Glenn L., "Early Eocene Bat from Wyoming," Science, CLIV (no. 3754, 1966), 1333-1339.

ES = 17 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 3.

60. Johnson, Gary D., "Small Mammals of the Middle Ogilocene of the Big Badlands of South Dakota," Proceedings of the South Dakota Academy of Science, XLV (1966), 78-83.

ES = 12 (1, 2, 3, 4, 5, 7, 8, 10, 11, 15, 17, 18); CS = 0.

61. Kenyon, W. A., "A Flake Tool and a Worked Antler Fragment from Late Lake Agassiz," Canadian Journal of Earth Science, II (no. 4, 1965), 237-246.

ES = 14 (1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

62. Kurten, Bjorn, "Fossil Bears from Texas," Pearce-Seilards Series Texas Memorial Museum, I (1965), 1-15.

ES = 16 (1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 0.

63. Landry, Stuart O., Jr., "The Status of the Theory of the Replacement of the Multituberculata by the Rodentia," Journal of Mammalogy, XLVI (no. 2, 1965), 280-286.

ES = 16 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 0.

64. Langston, Wann, Jr., "Limnosceloides brachycoles (Reptilla: Captorhino-morpha): A New Species from the Lower Permian of New Mexico," Journal of Paleontology, XL (no. 3, 1966), 690-695.

ES = 14 (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

65. Lazell, James D., Jr., "An Anolis (Sauria Iguanidae) in Amber," Journal of Paleontology, XXXIX (no. 3, 1965), 379-382.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 2.

66. Leonhardy, Frank C., "The Archaeology of the Domebo Site: Domebo, a Paleo-Indian Mammoth Kill in the Prairie Plains," Museum of the Great Plains Contributions (no. 1, 1966), 14-26.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

67. Lewis, George E., "Early Permian Vertebrates from the Cutler Formation of the Placerville Area, Colorado," U.S. Geological Survey Professional Paper (503-C, 1965), C1-C46.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

68. Lillegraven, Jason A., "Bison Crassicorni's and the Ground Sloth Megalonyx Jeffersoni in the Kansas Pleistocene," Transactions of the Kansas Academy of Science, LXIX (1966), 294-300.

ES = 14 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

69. McCullough, Dale R., "Elk Deposit on the San Francisco Peninsula," Journal of Mammalogy, XLVI (no. 2, 1965), 347-348.

ES = 9 (1, 4, 5, 6, 10, 11, 12, 13, 17, 18); CS = 0.

70. Macdonald, J. R., "The Varstovian Camp Creek Fauna from Elko County, Nevada," Los Angeles County Museum Contributions in Science (no. 2, 1966), 1-18.

71. McKenna, Malcom C., "Synopsis of Whitneyan and Arikareean Camelid Phylogeny," American Museum Novitates (no. 2253, 1966), 1-11.

ES = 10 (1, 2, 3, 4, 5, 10, 11, 17, 18, 19); CS = 0.

72. Martin, Paul S., "Africa and Pleistocene Overkill," Nature, CCXII (no. 5060, 1966), 339-342.

ES = 15 (1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 8.

73. Mawby, John E., "Machairodonts from the Late Cenozoic of the Panhandle of Texas," Journal of Mammalogy, XLVI (no. 4, 1965), 573-587.

ES = 15 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 15, 17, 18, 19); CS = 1.

74. Miller, Halsey W., Jr., "Cretaceous Dinosaurian Remains from Southern Arizona," Journal of Paleontology, XXXVIII (no. 2, 1964), 378-384.

ES = 16 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 0.

75. Milstead, William W., "Notes on the Identities of Some Poorly Known Fossils of Box Turtles (Terrapene)," Copeia (no. 4, 1965), 513-514.

ES = 11 (1, 2, 3, 4, 5, 7, 9, 10, 11, 17, 18); CS = 2.

76. Mitchell, Edward D., "A Walrus and a Sea Lion from the Pliocene Purisima Formation at Santa Cruz, California," Los Angeles County Museum Contributions in Science, LVI (1962), 1-24.

ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 1.

77. Morris, William J., "Fossil Mammals from Baja California--New Evidence on Early Tertiary Migrations," Science, CLIII (no. 3742, 1966), 1376-1378.

ES = 15 (1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 3.

78. Olson, Everett C., "Community Evolution and the Origin of Mammals," Ecology, XLVII (no. 2, 1966), 291-302.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 3.

79. Olson, Everett C., "Relationships of Diadectes," Fieldiana Geology, XIV (no. 10, 1966), 199-227.

ES = 15 (1, 2, 3, 4, 5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19); CS = 2.

80. Orr, Phil C., "The Fire Areas on Santa Rosa Island, California, Part 1," National Academy of Science Proceedings, LVI (no. 5, 1966), 1409-1416.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 2.

81. Mitchell, Edward, "The Miocene piniped Allodesmus," California University Publications in Geological Science, LXI (1966), 1-46.

ES = 15 (1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 17, 18); CS = 1.

82. Morris, William J., "Graphic Analysis of Some Miocene Horse Astragali from California," Journal of Paleontology, XXXIX (no. 4, 1965), 657-662.

ES = 14 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 14, 15, 17, 18); CS = 1.

83. Ostrom, John H., "Functional Morphology and Evolution of the Ceratopsian Dinosaurs," Evolution, XX (no. 3, 1966), 290-308.

ES = 16 (1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 1.

84. Parmalee, Paul W., "A Recent Record of Porcupine from Tennessee," Tennessee Academy of Science Journal, XLI (no. 3, 1966), 81-82.

ES = 9 (1, 2, 3, 5, 10, 11, 15, 17, 18); CS = 0.

85. Patton, Thomas H., "A New Genus of Fossil Microtine from Texas," Journal of Mammalogy, XLVI (no. 3, 1965), 466-471.

ES = 15 (1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 0.

86. Powell, Bernard W., "Spruce Swamp: A Partially Drowned Costal Midden in Connecticut," American Antiquity, XXX (no. 4, 1965), 460-469.

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ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 11.

180. Keith, M. L., "Local Variation of ^{13}C and ^{18}O Content of Mollusk Shells and the Relatively Minor Temperature Effect in Marginal Marine Environments," Marine Geology, III (no. 1-2, 1965), 115-129.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 5.

181. Kennedy, Vance C., "Mineralogy and Cation-Exchange Capacity of Sediments from Selected Streams," U.S. Geological Survey Professional Paper (no. 433-D, 1965), D1-D28.

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182. Kinkel, Arthur R., Jr., "Massive Pyritic Deposits Related to Volcanism, and Possible Methods of Emplacement," Economic Geology, LXI (1965), 673-694.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 8.

183. Krauskopf, K. B., "The Use of Thermochemical Data in Defining Conditions of High Temperature Ore Formation," Symposium on Problems of Postmagnetic Ore Deposition with Special Reference to the Geochemistry of Ore Veins, V2, Prague, Geological Survey of Czechoslovakia, 1965, 332-335.

ES = 17 (1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19); CS = 1.

184. Kuroda, P. K., "Galactic and Solar Nucelosynthesis," Nature, CCXII (no. 5059, 1966), 241-243.

ES = 14 (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15, 17, 18, 19); CS = 0.

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ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 7.

186. Liu, Po-Ling, "Laboratory Formation and Characterization of Taranakite in a Hydrol Humic Latosol Soil from Hawaii," Pacific Science, XX (no. 4, 1966), 496-506.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

187. Lowman, F. G., "Interactions of the Environmental and Biological Factors of the Distribution of Trace Elements in the Marine Environment," Symposium on Disposal of Radioactive Wastes into Seas, Oceans, and Surface Waters, 1966, Vienna, International Atomic Energy Agency, 1966, 249-266.

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188. MacKenzie, F. T., "Silicates--Radioactivity with Sea Water," Science, CL (no. 3692, 1965), 57-58.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 23.

189. Manuel, O. K., "Isotopic Composition of the Rare Gases in the Fayetteville Meteorite," Journal of Geophysical Research, LXIX (no. 7, 1964), 1413-1419.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19); CS = 20.

190. Mazor, E., "Helium, Neon, Argon, Krypton, and Xenon in Gas Emanations from Yellowstone and Lassen Volcanic National Parks," Geochimica et Cosmochimica Acta, XXIX (no. 5, 1965), 443-454.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 4.

191. Megrue, G. H., "Rare-Gas Chronology of Calcium-Rich Achondrites," Journal of Geophysical Research, LXXI (no. 16, 1966), 4021-4027.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 19.

192. Merrihue, Craig, "Xenon and Krypton in the Braderheim Meteorite," Journal of Geophysical Research, LXXI (no. 1, 1966), 263-313.

ES = 19 (ALL); CS = 27.

193. Middleton, K. R., "Determination of Aluminum and Iron and the Relation of Aluminum to Clay in Certain Tropical Soils," Soil Science, C (no. 5, 1965), 361-367.

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ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19); CS = 2.

195. Milliman, John D., "Submarine Lithification of Carbonate Sediments," Science, CLIII (no. 3739, 1966), 994-997.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 26.

196. Mohr, P. A., "Further Considerations on the Deposition of the Middle Cambrian Manganese Carbonate Beds of Wales and New Foundland," Geological Magazine, CII (no. 4, 1965), 328-337.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18); CS = 0.

197. Murthy, V. Rama, "Rb-Sr Ages of Chondrules and Carbonaceous Chondrites," Journal of Geophysical Research, LXX (no. 20, 1965), 5297-5307.

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198. Nandi, S. P., "Diffusion of Argon from Coals of Different Rank," Coal Science, Washington, D. C., American Chemical Society, 1966, 379-385.

ES = 15 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 3.

199. Naumann, A. W., "The Influence of Sample Texture on Chrysotile Dehydroxylation," American Mineralogist, LI (no. 7, 1966), 1200-1211.

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201. Northrop, David A., "Oxygen-Isotope Fractionations in Systems Containing Dolomite," Journal of Geology, LXXIV (no. 2, 1966), 174-196.

ES = 19 (ALL); CS = 24.

202. O'Neil, James R., "A Method for Oxygen Isotope Analysis of Milligram Quantities of Water and Some of Its Applications," Journal of Geophysical Research, LXXI (no. 20, 1966), 4955-4961.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19); CS = 8.

203. Ong, H. Ling, "Adsorption of Copper by Peat, Lignite, and Bituminous Coal," Economic Geology, LXI (no. 7, 1966, 1214-1231.

ES = 15 (1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 18); CS = 1.

204. Pepin, Robert O., "Heavy Rare Gases in Silicates from the Estherville Mesosiderite," Journal of Geophysical Research, LXXI (no. 11, 1966), 2815-2829.

ES = 19 (ALL); CS = 25.

205. Perkins, R. W., "Chlorine-38 and Sulpher-38 Produced by Cosmic Radiation," Nature, CCV (no. 4973, 1965), 790-791.

ES = 13 (1, 2, 3, 4, 5, 6, 7, 9, 10, 12, 14, 17, 18); CS = 0.

206. Pilkey, Orrin H., "The Effect of Intertidal Environment on the Composition of Calcareous skeletal Material," Limnology and Oceanography, II (no. 3, 1966), 381-385.

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207. Polzer, W. L., "The Dissolution of Kalonite," Journal of Geophysical Research, LXX (no. 24, 1965), 6233-6240.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 5.

208. Poschenrieder, Walter P., "The Relative Abundance of the Lithium Isotopes in the Holbrook Meteorite," Geochimica et Cosmochimica Acta, XXIX (no. 11, 1965), 1193-1965.

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209. Powell, J. L., "Isotopic Composition of Strontium in Volcanic Rocks from Oahu," Science, CLIII (no. 3741, 1966), 1239-1242.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 13.

210. Pytkowicz, R. M., "Rates of Inorganic Calcium Carbonate Nucleation," Journal of Geology, LXXIII (no. 1, 1965), 196-199.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 7.

211. Raman, K. V., "Layer Charge Relations in Clay Minerals of Micaceous Soils and Sediments," Clay and Clay Science, Proceedings of the 14th National Conference, New York, Pergamon Press, 1966, 53-69.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 7.

212. Reed, M. G., "Chemical Extraction of Potassium from Soils and Micaceous Minerals with Solutions Containing Sodium Tetraph-Enylboron, Part 4, Muscovite," Soil Science Society of America Proceedings, XXX (no. 2, 1966), 185-188.

ES = 17 (1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19); CS = 4.

213. Reuter, J. H., "O^{18}/O^{16} Ratios of Some Chrondrite Meteorites and Terrestrial Ultramafic Rocks," Geochimica et Cosmochimica Acta, XXIX (no. 5, 1965), 481-488.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19); CS = 5.

214. Ringwood, A. E., "The Chemical Composition and Origin of the Earth," Advances in Earth Science, Proceedings of the International Conference, 1964, Cambridge, Massachusetts, MIT Press, 1966, 287-356.

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215. Roberson, Charles E., "Solubility Implications of Apatite in Sea Water," U.S. Geological Survey Professional Paper, (no. 550D, 1966), D178-D185.

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ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 16.

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ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 2.

218. Rowe, M. W., "Cosmic Ray Produced Xenon in Meteorites," Physics Review Letters, XV (no. 22, 1965), 843-845.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 17.

219. Rowe, M. W., "Isotopic Composition of Xenon from Ca-Poor Achondrites," Journal of Geophysical Research, LXXI (no. 17, 1966), 4183-4188.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 9.

220. Rowe, M. W., "Mass Yield Spectrum of Cosmic Ray Produced Xenon," Journal of Geophysical Research, LXXI (no. 19, 1966), 4679-4684.

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ES = 16 (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 4.

222. Rye, Robert O., "The Carbon, Hydrogen and Oxygen Isotopic Composition of the Hydrothermal Fluids Responsible for the Lead-Zinc Deposits at Providencia, Zacatecas, Mexico," Economic Geology, LXI (no. 8, 1966), 1399-1427.

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ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 7.

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ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 18); CS = 4.

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ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18, 19); CS = 12.

226. Schwarcz, H. P., "Oxygen and Carbon Isotopic Fractionation Between Co-Existing Metamorphic Calcite and Dolmite," Journal of Geology, LXXIV (no. 1, 1966), 38-48.

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227. Sharma, Taleshwar, "O^{18}/O^{16} Ratios of Minerals from the Iron Formations of Quebec," Journal of Geology, LXXIII (no. 4, 1965), 664-667.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 17.

228. Shaw, D. M., "A Review of Boron Sedimentary Geochemistry in Relation to New Analysis of Some North American Shales," Canadian Journal of Earth Science, III (no. 1, 1966), 49-63.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19); CS = 8.

229. Sharp, W. E., "The Composition of Hydrothermal Quartz and Calcite," Economic Geology, LX (no. 8, 1965), 1635-1644.

ES = 13 (1, 2, 3, 4, 6, 8, 9, 10, 11, 15, 16, 17, 18); CS = 0.

230. Simpson, Dale R., "Experiments on the Precipitation of Salt from Sea Water," Pennsylvania Academy of Science Proceedings, XXXVIII (no. 2, 1965), 168-169.

ES = 12 (1, 4, 6, 7, 10, 11, 12, 13, 15, 17, 18); CS = 0.

231. Smith, S. J., "Extractable Potassium in Grundite Illite, Part 1, Method of Extraction," Soil Science, CII (no. 2, 1966), 115-122.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 0.

232. Spotts, J. H., "Organic Dolomite from Point Fermin, California," American Mineralogist, LI (1966), 1144-1155.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 6.

233. Steiger, Rudolf H., "Systematics in the Pb^{208}-Th^{232}, Pb^{207}-U^{238} Systems," Journal of Geophysical Research, LXXI (no. 24, 1966), 6065-6090.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 10.

234. Stueber, Alan M., "Strontium Isotope and Alkali Element Abundance in Ultramafic Rocks," Geochimica et Cosmochimica Acta, XXX (no. 12, 1966), 1234-1259.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 29.

235. Thode, H. G., "Sulphur-Isotope Geochemistry of Petroleum, Evaporates, and Ancient Stones," American Association of Petroleum Geology Memoir, IV (1965), 367-377.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18); CS = 5.

236. Truesdell, A. H., "Ion-Exchange Constants of Natural Classes by the Electrode Method," American Mineralogist, LI (no. 1-2, 1966), 110-122.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 5.

237. Turekian, Karl L., "The Distribution of Trace Elements in Deep Sea Sediments of the Atlantic Ocean," Earth and Planetary Science Letters, I (no. 9, 1966), 161-168.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 5.

238. Turner, R. C., "Factors Affecting the Solubility of $Al(OH)_3$ Precipitated in the Presence of Montmorilonite," Soil Science, C (no. 3, 1965), 176-181.

ES = 17 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18); CS = 9.

239. Weber, Jon A., "Oxygen Isotope Fractionation Between Coexisting Calcite and Dolmite in the Fresh Water Upper Carboniferous Freeport Formation," Nature, CCVII (no. 5000, 1965), 972-973.

ES = 13 (1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 15, 17, 19); CS = 2.

240. Weissberg, B. G., "Solubility of Pigment (As_2S_3) in Na_2S-H_2O at 50-200°C and 100-1,500 bars with Geological Applications," Geochimica et Cosmochimica Acta, XXX (no. 8, 1966), 815-827.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 2.

241. Zartman, Robert E., "The Isotopic Composition of Lead in Microclines from the Llano Uplift, Texas," Journal of Geophysical Research, LXX (no. 4, 1965), 965-975.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 10.

242. Gloyna, E. F., "Transport of Radionuclides in a Model River," Disposal of Radioactive Wastes into Seas, Oceans, and Surface Waters, Symposium, Vienna, 1966, Vienna, International Atomic Energy Agency, 1966, 11-32.

ES = 16 (1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18); CS = 1.

243. Perkins, R. W., "Chlorine-38 and Sulphur-38 Produced by Cosmic Radiation,' Nature, CCV (1965), 790-791.

ES = 18 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19); CS = 10.

244. Scott, A. D., "Susceptibility of Interlayer Potassium in Micas to Exchange with Sodium," Clays and Clay Minerals: National Conference, 1965, New York, Pergamon Press, 1966, 69-81.

ES = 16 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 17, 18); CS = 9.

APPENDIX E

TABLE XI

EVALUATION INSTRUMENT RE-TEST

Sample Item Number	Evaluation Item Number Displaying Change	Original	Re-Test
1	4	0	1
4	-	-	-
8	-	-	-
25	-	-	-
35	-	-	-
59	-	-	-
66	-	-	-
69	8	1	0
74	12	1	0
	13	1	0
91	-	-	-
97	16	1	0
103	-	-	-
114	-	-	-
164	-	-	-
167	-	-	-
170	6	0	1
	19	0	1
175	-	-	-
179	-	-	-
206	-	-	-
210	-	-	-
211	-	-	-
223	12	1	0
229	-	-	-
234	-	-	-
244	-	-	-

APPENDIX F

TABLE XII

UNIVARIATE FREQUENCY DISTRIBUTION FOR THE EVALUATION SCORES FOR THE COMBINED SUBFIELDS

Score	Absolute Frequency	Relative Frequency (%)
8	3	1.2
9	6	2.5
10	2	0.8
11	11	4.5
12	13	5.3
13	18	7.4
14	33	13.5
15	31	12.7
16	49	20.1
17	44	18.0
18	26	10.7
19	8	3.3
	Total 244	Total 100.0

TABLE XIII

UNIVARIATE FREQUENCY DISTRIBUTION OF THE CITATIONS FOR THE COMBINED SUBFIELDS

Citation Count	Absolute Frequency	Relative Frequency (%)
0	91	37.3
1	34	13.9
2	20	8.2
3	15	6.1
4	11	4.5
5	12	4.9
6	5	2.0
7	10	4.1
8	7	2.9
9	2	0.8
10	5	2.0
11	2	0.8
12	2	0.8
13	2	0.8
16	2	0.8
17	3	1.2
18	1	0.4
19	2	0.8
20	1	0.4
22	3	1.2
23	3	1.2
24	1	0.4
25	1	0.4
26	2	0.8
27	1	0.4
28	1	0.4
29	1	0.4
33	2	0.8
35	1	0.4
52	1	0.4
	Total 244	Total 100.0

TABLE XIV

UNIVARIATE FREQUENCY DISTRIBUTION OF THE EVALUATION SCORES FOR GEOCHEMISTRY

Score	Absolute Frequency	Relative Frequency (%)
11	1	0.8
12	4	3.3
13	7	5.7
14	12	9.9
15	9	7.4
16	23	18.9
17	33	27.0
18	25	20.5
19	8	6.6
	Total 122	Total 100.0

TABLE XV

UNIVARIATE FREQUENCY DISTRIBUTION OF THE CITATIONS FOR GEOCHEMISTRY

Citation Count	Absolute Frequency	Relative Frequency (%)
0	20	16.4
1	10	8.2
2	8	6.6
3	10	8.2
4	8	6.6
5	12	9.8
6	4	3.3
7	10	8.2
8	5	4.1
9	2	1.6
10	5	4.1
11	2	1.6
12	2	1.6
13	2	1.6
16	1	0.8
17	2	1.6
18	1	0.8
19	2	1.6
20	1	0.8
22	3	2.5
23	2	1.6
24	1	0.8
25	1	0.8
26	1	0.8
27	1	0.8
28	1	0.8
29	1	0.8
33	2	1.6
35	1	0.8
52	1	0.8
	Total 122	Total 100.0

TABLE XVI

UNIVARIATE FREQUENCY DISTRIBUTION OF THE EVALUATION SCORES FOR VERTEBRATE PALEONTOLOGY

Score	Absolute Frequency	Relative Frequency (%)
8	3	2.5
9	6	4.9
10	2	1.6
11	10	8.2
12	9	7.4
13	11	9.0
14	21	17.2
15	22	18.0
16	26	21.3
17	11	9.0
18	1	0.8
	Total 122	Total 100.0

TABLE XVII

UNIVARIATE FREQUENCY DISTRIBUTION OF THE CITATIONS FOR VERTEBRATE PALEONTOLOGY

Citation	Absolute Frequency	Relative Frequency (%)
0	71	58.2
1	24	19.7
2	12	9.8
3	5	4.1
4	3	2.5
6	1	0.8
8	2	1.6
16	1	0.8
17	1	0.8
23	1	0.8
26	1	0.8
	Total 122	Total 100.0

TABLE XVIII

UNIVARIATE FREQUENCY DISTRIBUTION OF THE LISTING IN AMERICAN MEN OF SCIENCE OF PRIMARY AUTHOR FOR THE COMBINED SUBFIELDS

Listing	Absolute Frequency	Relative Frequency (%)
Yes	171	70.1
No	73	29.9
	Total 244	Total 100.0

TABLE XIX

UNIVARIATE FREQUENCY DISTRIBUTION FOR THE RANK OF GRADUATE FACULTY IN CARTTER REPORT OF PRIMARY AUTHOR FOR THE COMBINED SUBFIELDS

Rank	Absolute Frequency	Relative Frequency (%)
1	7	2.9
2	11	4.5
3	13	5.3
4	2	0.8
5	13	5.3
6	10	4.1
7	2	0.8
8	4	1.6
10	1	0.4
11	5	2.0
14	1	0.4
16	1	0.4
18	9	3.7
20	1	0.4
Unranked	164	67.2
	Total 244	Total 100.0

TABLE XX

UNIVARIATE FREQUENCY DISTRIBUTION OF THE RANK OF GRADUATE PROGRAM IN CARTTER REPORT OF PRIMARY AUTHOR FOR THE COMBINED SUBFIELDS

Rank	Absolute Frequency	Relative Frequency (%)
1	10	4.1
2	22	9.0
3	2	0.8
4	8	3.3
5	10	4.1
6	4	1.6
7	3	1.2
9	3	1.2
10	4	1.6
11	5	2.0
14	7	2.9
15	2	0.8
17	5	2.0
18	1	0.4
Unranked	158	64.8
	Total 244	Total 100.0

TABLE XXI

UNIVARIATE FREQUENCY DISTRIBUTION OF THE GEOGRAPHIC LOCATION OF EMPLOYMENT OF PRIMARY AUTHOR FOR THE COMBINED SUBFIELDS

Location	Absolute Frequency	Relative Frequency (%)
North	56	23.0
South	37	15.2
North Central	49	20.1
West	70	28.7
Other	25	10.2
Unknown	7	2.9
	Total 244	Total 100.0

TABLE XXII

UNIVARIATE FREQUENCY DISTRIBUTION OF THE GENDER OF PRIMARY AUTHOR FOR THE COMBINED SUBFIELDS

Gender	Absolute Frequency	Relative Frequency (%)
Male	201	82.4
Female	10	4.1
Unknown	33	13.5
	Total 244	Total 100.0

TABLE XXIII

UNIVARIATE FREQUENCY DISTRIBUTION OF THE TYPE OF INSTITUTION EMPLOYING PRIMARY AUTHOR FOR THE COMBINED SUBFIELDS

Type of Institution	Absolute Frequency	Relative Frequency (%)
Academic	162	66.4
Federal or State Government	36	14.8
Industry	12	4.9
Other	26	10.7
Unknown	8	3.3
	Total 244	Total 100.0

APPENDIX G

TABLE XXIV

BIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE CITATIONS FOR THE COMBINED SUBFIELDS

Citations	Grouped Evaluation Scores 8-15		Grouped Evaluation Scores 16-19	
0	72	(N)	19	(N)
	29.5	%	7.8	%
1	21	(N)	13	(N)
	8.6	%	5.3	%
2	9	(N)	11	(N)
	3.7	%	4.5	%
3	7	(N)	8	(N)
	2.9	%	3.3	%
4	3	(N)	8	(N)
	1.2	%	3.3	%
5	0	(N)	12	(N)
	0.0	%	4.9	%
6	1	N)	4	(N)
	0.4	%	1.6	%
7	0	(N)	10	(N)
	0.0	%	4.1	%
8	1	(N)	6	(N)
	0.4	%	2.5	%
9	0	(N)	2	(N)
	0.0	%	0.8	%
10	0	(N)	5	(N)
	0.0	%	2.0	%
11	0	(N)	2	(N)
	0.0	%	0.8	%
12	0	(N)	2	(N)
	0.0	%	0.8	%
13	0	(N)	2	(N)
	0.0	%	0.8	%
16	1	(N)	1	(N)
	0.4	%	0.4	%
17	1	(N)	2	(N)
	0.4	%	0.8	%
18	0	(N)	1	(N)
	0.0	%	0.4	%

TABLE XXIV--Continued

Citations	Grouped Evaluation Scores			
	8-15		16-19	
19	0	(N)	2	(N)
	0.0	%	0.8	%
20	0	(N)	1	(N)
	0.0	%	0.4	%
22	1	(N)	2	(N)
	0.4	%	0.8	%
23	0	(N)	3	(N)
	0.0	%	1.2	%
24	0	(N)	1	(N)
	0.0	%	0.4	%
25	0	(N)	1	(N)
	0.0	%	0.4	%
26	0	(N)	2	(N)
	0.0	%	1.6	%
27	0	(N)	1	(N)
	0.0	%	0.4	%
28	0	(N)	1	(N)
	0.0	%	0.4	%
29	0	(N)	1	(N)
	0.0	%	0.4	%
33	0	(N)	2	(N)
	0.0	%	0.8	%
35	0	(N)	1	(N)
	0.0	%	0.4	%
52	0	(N)	1	(N)
	0.0	%	0.4	%

Per cent figures for all tables rounded to nearest tenth.

TABLE XXV

BIVARIATE FREQUENCY DISTRIBUTION FOR THE EVALUATION SCORES BY THE SUBFIELD GROWTH RATE

		Growth Rate of Subfield			
		Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Score	8	3 1.2	(N) %	0 0.0	(N) %
	9	6 2.5	(N) %	0 0.0	(N) %
	10	2 0.8	(N) %	0 0.0	(N) %
	11	10 4.1	(N) %	1 0.4	(N) %
	12	9 3.7	(N) %	4 1.6	(N) %
	13	11 4.5	(N) %	7 2.9	(N) %
	14	21 8.6	(N) %	12 4.9	(N) %
	15	22 9.0	(N) %	9 3.7	(N) %
	16	26 10.7	(N) %	23 9.4	(N) %
	17	11 4.5	(N) %	33 13.5	(N) %
	18	1 0.4	(N) %	25 10.2	(N) %
	19	0 0.0	(N) %	8 3.3	(N) %

TABLE XXVI

BIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Grouped Scores				
8-15	84 34.4	(N) %	33 13.5	(N) %
16-19	38 15.5	(N) %	89 36.4	(N) %

TABLE XXVII

BIVARIATE FREQUENCY DISTRIBUTION FOR THE SUBFIELD GROWTH RATE BY THE LISTING IN AMERICAN MEN OF SCIENCE OF THE PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Listed	89 36.4	(N) %	82 33.6	(N) %
Unlisted	33 13.5	(N) %	40 16.3	(N) %

TABLE XXVIII

BIVARIATE FREQUENCY DISTRIBUTION FOR THE SUBFIELD GROWTH RATE BY THE RANK OF GRADUATE FACULTY IN CARTTER REPORT OF PRIMARY AUTHOR

		Growth Rate of Subfield			
		Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Rank	1	4 1.6	(N) %	3 1.2	(N) %
	2	9 3.6	(N) %	2 0.8	(N) %
	3	1 0.4	(N) %	12 4.9	(N) %
	4	0 0.0	(N) %	2 0.8	(N) %
	5	9 3.6	(N) %	4 1.6	(N) %
	6	5 2.0	(N) %	5 2.0	(N) %
	7	0 0.0	(N) %	2 0.8	(N) %
	8	1 0.4	(N) %	3 1.2	(N) %
	10	0 0.0	(N) %	1 0.4	(N) %
	11	1 0.4	(N) %	4 1.6	(N) %
	14	1 0.4	(N) %	0 0.0	(N) %
	16	1 0.4	(N) %	0 0.0	(N) %
	18	9 3.6	(N) %	0 0.0	(N) %
	20	1 0.4	(N) %	0 0.0	(N) %
	Unranked	80 32.7	(N) %	84 34.4	(N) %

TABLE XXIX

BIVARIATE FREQUENCY DISTRIBUTION FOR THE SUBFIELD GROWTH RATE BY THE RANK OF GRADUATE PROGRAM IN CARTTER REPORT OF PRIMARY AUTHOR

		Growth Rate of Subfield			
		Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Rank	1	5 2.0	(N) %	5 2.0	(N) %
	2	10 4.0	(N) %	12 4.9	(N) %
	3	0 0.0	(N) %	2 0.8	(N) %
	4	5 2.0	(N) %	3 1.2	(N) %
	5	6 2.4	(N) %	4 1.6	(N) %
	6	0 0.0	(N) %	4 1.6	(N) %
	7	1 0.4	(N) %	2 0.8	(N) %
	9	1 0.4	(N) %	2 0.8	(N) %
	10	1 0.4	(N) %	3 1.2	(N) %
	11	5 2.0	(N) %	0 0.0	(N) %
	14	7 2.8	(N) %	0 0.0	(N) %
	15	2 0.8	(N) %	0 0.0	(N) %
	17	4 1.6	(N) %	1 0.4	(N) %
	18	1 0.4	(N) %	0 0.0	(N) %
	Unable to Determine	74 30.3	(N) %	84 34.4	(N) %

TABLE XXX

BIVARIATE FREQUENCY DISTRIBUTION FOR THE SUBFIELD GROWTH RATE BY THE GEOGRAPHIC LOCATION OF EMPLOYMENT OF PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology		Rapid (Geochemistry)	
Place				
Northwest	32 13.1	(N) %	24 9.8	(N) %
South	16 6.5	(N) %	21 8.6	(N) %
North Central	33 13.5	(N) %	16 6.5	(N) %
West	28 11.4	(N) %	42 17.2	(N) %
Other	8 3.2	(N) %	17 6.9	(N) %
Unable to Determine	5 2.0	(N) %	2 0.8	(N) %

TABLE XXXI

BIVARIATE FREQUENCY DISTRIBUTION FOR THE SUBFIELD GROWTH RATE BY THE GENDER OF PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Gender				
Male	114 46.7	(N) %	87 35.6	(N) %
Female	5 2.0	(N) %	5 2.0	(N) %
Unable to Determine	3 1.2	(N) %	30 12.2	(N) %

TABLE XXXII

BIVARIATE FREQUENCY DISTRIBUTION FOR THE SUBFIELD GROWTH RATE WITH THE TYPE OF INSTITUTION EMPLOYING PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
Type of Institution				
Academic	90 36.8	(N) %	72 29.5	(N) %
Federal or State Government	6 2.4	(N) %	30 12.2	(N) %
Industry	1 0.4	(N) %	11 4.5	(N) %
Other	19 7.7	(N) %	7 2.8	(N) %
Unable to Determine	6 2.4	(N) %	2 0.8	(N) %

TABLE XXXIII

TRIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE BY THE LISTING IN AMERICAN MEN OF SCIENCE OF PRIMARY AUTHOR

Grouped Scores	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
	Unlisted	Listed	Unlisted	Listed
8-15	20 (N) 8.2 %	64 (N) 26.2 %	14 (N) 5.7 %	19 (N) 7.7 %
16-19	13 (N) 5.3 %	25 (N) 10.2 %	26 (N) 10.6 %	63 (N) 25.8 %

TABLE XXXIV

TRIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE BY THE RANK OF GRADUATE FACULTY IN CARTTER REPORT OF PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
	Grouped Scores 8-15	16-19	Grouped Scores 8-15	16-19
Rank				
1	1 (N) 0.4 %	3 (N) 1.2 %	1 (N) 0.4 %	2 (N) 0.8 %
2	6 (N) 2.4 %	3 (N) 1.2 %	0 (N) 0.0 %	2 (N) 0.8 %
3	1 (N) 0.4 %	0 (N) 0.0 %	1 (N) 0.4 %	11 (N) 4.5 %
4	0 (N) 0.0 %	0 (N) 0.0 %	0 (N) 0.0 %	2 (N) 0.8 %
5	7 (N) 2.8 %	2 (N) 0.8 %	1 (N) 0.4 %	3 (N) 1.2 %
6	4 (N) 1.6 %	1 (N) 0.4 %	1 (N) 0.4 %	4 (N) 1.6 %
7	0 (N) 0.0 %	0 (N) 0.0 %	1 (N) 0.4 %	1 (N) 0.4 %
8	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	3 (N) 1.2 %
10	0 (N) 0.0 %	0 (N) 0.0 %	1 (N) 0.4 %	0 (N) 0.0 %
11	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	4 (N) 1.6 %
14	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	0 (N) 0.0 %
16	1 (N) 0.4 %	1 (N) 0.4 %	1 (N) 0.4 %	1 (N) 0.4 %
18	6 (N) 2.4 %	3 (N) 1.2 %	0 (N) 0.0 %	0 (N) 0.0 %
20	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	0 (N) 0.0 %
Unranked	54 (N) 22.1 %	26 (N) 10.6 %	27 (N) 11.0 %	57 (N) 23.3 %

TABLE XXXV

TRIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE BY THE RANK OF GRADUATE PROGRAM IN CARTTER REPORT OF PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
	Grouped Scores		Grouped Scores	
Rank	8-15	16-19	8-15	16-19
1	2 (N) 0.8 %	3 (N) 1.2 %	2 (N) 0.8 %	3 (N) 1.2 %
2	6 (N) 2.4 %	4 (N) 1.6 %	1 (N) 0.4 %	11 (N) 4.5 %
3	0 (N) 0.0 %	0 (N) 0.0 %	0 (N) 0.0 %	2 (N) 0.8 %
4	4 (N) 1.6 %	1 (N) 0.4 %	0 (N) 0.0 %	3 (N) 1.2 %
5	5 (N) 2.0 %	1 (N) 0.4 %	1 (N) 0.4 %	3 (N) 1.2 %
6	0 (N) 0.0 %	0 (N) 0.0 %	2 (N) 0.8 %	2 (N) 0.8 %
7	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	2 (N) 0.8 %
9	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	2 (N) 0.8 %
10	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	3 (N) 1.2 %
11	4 (N) 1.6 %	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %
14	5 (N) 2.0 %	2 (N) 0.8 %	0 (N) 0.0 %	0 (N) 0.0 %
15	2 (N) 0.8 %	0 (N) 0.0 %	0 (N) 0.0 %	0 (N) 0.0 %
17	3 (N) 1.2 %	1 (N) 0.4 %	0 (N) 0.0 %	1 (N) 0.4 %
18	1 (N) 0.4 %	0 (N) 0.0 %	0 (N) 0.0 %	0 (N) 0.0 %
Unranked	49 (N) 20.0 %	25 (N) 10.2 %	27 (N) 11.0 %	57 (N) 23.3 %

TABLE XXXVI

TRIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE BY THE GEOGRAPHIC LOCATION OF EMPLOYMENT OF PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
	Grouped Scores 8-15	16-19	8-15	16-19
Place				
North	21 (N) 8.6 %	11 (N) 4.5 %	8 (N) 3.2 %	16 (N) 6.5 %
South	10 (N) 4.0 %	6 (N) 2.4 %	6 (N) 2.4 %	15 (N) 6.1 %
North Central	24 (N) 9.8 %	9 (N) 3.6 %	4 (N) 1.6 %	12 (N) 4.9 %
West	21 (N) 8.6 %	7 (N) 2.8 %	9 (N) 3.6 %	33 (N) 13.5 %
Other	6 (N) 2.4 %	2 (N) 0.8 %	4 (N) 1.6 %	13 (N) 5.3 %
Unknown	2 (N) 0.8 %	3 (N) 1.2 %	2 (N) 0.8 %	0 (N) 0.0 %

TABLE XXXVII

TRIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE BY THE GENDER OF PRIMARY AUTHOR

Grouped Scores	Growth Rate of Subfield					
	Slow (Vertebrate Paleontology)			Rapid (Geochemistry)		
	Male	Female	Unknown	Male	Female	Unknown
8-15	78 (N) 31.9 %	4 (N) 1.6 %	2 (N) 0.8 %	17 (N) 6.9 %	3 (N) 1.2 %	13 (N) 5.3 %
16-19	36 (N) 14.7 %	1 (N) 0.4 %	1 (N) 0.4 %	70 (N) 28.6 %	2 (N) 0.8 %	17 (N) 6.9 %

TABLE XXXVIII

TRIVARIATE FREQUENCY DISTRIBUTION FOR THE GROUPED EVALUATION SCORES BY THE SUBFIELD GROWTH RATE BY THE TYPE OF INSTITUTION EMPLOYING PRIMARY AUTHOR

	Growth Rate of Subfield			
	Slow (Vertebrate Paleontology)		Rapid (Geochemistry)	
	Grouped Scores 8-15	16-19	8-15	16-19
Type of Institution				
Academic	62 (N) 25.4 %	28 (N) 11.4 %	19 (N) 7.7 %	53 (N) 21.7 %
Federal or State Government	4 (N) 1.6 %	2 (N) 0.8 %	5 (N) 2.0 %	25 (N) 10.2 %
Industry	1 (N) 0.4 %	0 (N) 0.0 %	4 (N) 1.6 %	7 (N) 2.8 %
Other	14 (N) 5.7 %	5 (N) 2.0 %	3 (N) 1.2 %	4 (N) 1.6 %
Unable to Determine	3 (N) 1.2 %	3 (N) 1.2 %	2 (N) 0.8 %	0 (N) 0.0 %

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