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Citation Patterns of Environmental Scientists and Biologists at the University of Massachusetts at Boston: Implications for Library Collection Development

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CITATION PATTERNS OF ENVIRONMENTAL SCIENTISTS AND BIOLOGISTS AT THE UNIVERSITY OF MASSACHUSETTS AT BOSTON: IMPLICATIONS FOR LIBRARY COLLECTION DEVELOPMENT

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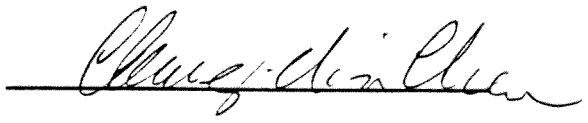

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ABSTRACT

**CITATION PATTERNS
OF THE ENVIRONMENTAL SCIENTISTS AND BIOLOGISTS
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This study investigates the citation patterns of environmental scientists and biologists at the University of Massachusetts at Boston (UMB). The citation patterns of these academic scientists are compared to those in *Journal Citations Reports* (*JCR*).

The findings suggest that the UMB environmental scientists and biologists have similar citation patterns to those of other scientists. There are differences in the median age of the journal cited by these scientists when compared to *JCR*. Yet the age of the items cited suggests that the library can weed some pre-1960 journals with minimal effect on the effectiveness of the library to satisfy the needs of these scientists.

The journals cited by the UMB environmental scientists and biologists were broken down by subject category. The citation frequency of the journals cited by these UMB scientists was compared to that of *JCR*. Some difference was found between the citation patterns of the UMB environmental scientists and biologists with those of *JCR* by subject category. This suggests that *JCR* might be used at HL for collection development.

The study findings suggest journal subscriptions that are potential candidates for cancellation. A list of journals that are potential candidates for acquisition at the UMB Healey Library (HL) is identified. The findings of this study also suggest that HL's effectiveness in satisfying the citation needs of the UMB environmental scientists and

biologists is lower than expected when compared to the findings of other studies. The findings suggest that HL must provide a multi-subject science journal collection to satisfy the need of these scientists within the constraints of available fiscal and physical resources.

The findings also suggest minimal library material fund allocations for the different publication forms cited by the UMB environmental scientists and biologists.

Finally, the citation patterns of the UMB environmental scientists suggest that these scientists conform to "normal science". Thus, the UMB environmental scientists and biologists rely on journals more than any other publication form; their journal citation scattering conforms to Bradford's Law of Scattering; and the citation frequency rankings of the journals cited by these scientists were statistically similar to those of *JCR*. Contrary to the belief of a few science historians, these environmental scientists conform to the prevailing "norms and rules" of science.

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Chapter 1

INTRODUCTION

In this century, new scientific disciplines develop either as separate fields or as sub-specialties of others. Such is the case of Environmental Sciences[1] which, in the last forty years, emerged as a field by itself, and more recently, Environmental Biology[2] which is generally identified as a branch of the Biological Sciences.

The emergence of environmental sciences has attracted the interest of a few science historians. For example, Bowler in his 1992 book on the history of the environmental sciences noted that this field is different from others. In discussing this he said that (p. 3):

> ... the very term "environmental sciences" has a modern context that would not have been recognized by scientists of earlier generations. Twentieth-century science has become highly specialized, and the research programs of disciplines often differ in character even when - to the outsider - they seem to be dealing with closely related topics. ... The unity of the "environmental sciences" is not created by the sciences themselves; it is imposed by the public's growing awareness of the threat posed to the environment by our own activities. ... To create a unified group of environmental sciences forces the scientists themselves to take a broader perspective, this will merely revive a sense of unity that has been lost in the period of increased specialization.

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[1]Environmental sciences is a discipline where "basic and applied scientific inquiry about changes in the environmental quality resulting from the activities of man." (R. Metcalf. ***Advances in Environmental Sciences***, 1969, v. 1, p. 1.)

[2]Environmental biology is "applied ecology that studies the effect of humans on their environment and survival of other species." (***New Encyclopedia Britannica***, 1993. 4, 354.)

Here, Bowler expresses his belief that the environmental sciences show a unique relationship between science and changing cultural values. According to him, this relationship causes the emergence of new scientific paradigm that responds to the shifts in attitudes and changes in cultural values towards nature. Bowler elaborated on the nature of science, the scientific method and the forces that shape these when he said that (p. 16):

> The scientific method guarantees that subjective factors such as philosophical and religious beliefs cannot be incorporated into the framework of knowledge. But can we really accept that science has been able to emancipate itself so completely from the world of human beliefs and feelings? Our perception of the world is almost inevitably dictated by cultural factors, and the rise of materialism itself can be counted as just such a factor. The creation of what now we call the "environmental sciences" raises a series of questions centered on our definition of sciences and our understanding of how the functioning of science itself shapes our perception of the world.

It is clear that Bowler believes that the environmental sciences offer evidence in favor of his hypothesis -- that scientific inquiry can be affected by changing values and external/internal pressures. Yet, before Bowler, another science historian, Kuhn (1970) said that science works based on unspoken norms and rules, and those of current scientific practice are what he called "normal science".

According to Kuhn, these norms and rules affect and govern the nature of scientific research and communication, as they impact the interpretation of experimental findings and the development of new theories. Kuhn also noted, that for the development of new scientific practices and discoveries, changes or shifts in science norms and rules have to take place. These changes are what he called "shifting paradigms". These shifts are necessary precursors that allow "revolution" in science that impact scientific research,

theories, and eventually affect communication between scientists. Kuhn said that science is rooted on previous experimentally tested knowledge, but that science is also rooted on scientists' commitment to concepts, theoretical notions and points of view tied to a specific discipline's "culture".[3]

This analysis is clearly present in Bowler's interpretation of the history of environmental sciences when he said (pp. 24-25):

> An important lead offered by Kuhn's scheme is its emphasis on the role played by the scientific community. The followers of a paradigm have a professional loyalty to the scheme they inherited, and a scientific revolution depends upon the creation of a new elite within the community that takes over control of the sources of funding, the means of publication and the educational establishment. ... The paradigms of Kuhn's scheme are theories that impose a fundamental structure upon our view of the world. They define the research schools and thus represent professional loyalties that may shape the whole of a scientist's career. Because they model Nature at such deep level, they involve components that represent philosophical and sometimes even religious commitments."

Here Bowler once more restates his belief that the environmental sciences are a new scientific paradigm that is growing and taking control over funding sources and gaining the educational establishment.

Yet in addition to this view other authors have looked upon the nature of environmental sciences and have identified it as an interdisciplinary field. For example, Hurd (1992, p.283), in discussing this and other fields said their research is focused on problem-solving:

> In these fields scientists trained in diverse disciplines come together to work on problems or projects that demand broad-based perspectives or

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[3]Refer to Kuhn's work ***The Structure of Scientific Revolutions*** for a lengthy discussion.

apply techniques developed in one field to research in another.

Therefore, it is expected that scientists in these new fields resort to different bodies of core literature for research, teaching, publishing, and communication. In addition to this, Kuhn's and Bowler's analyses suggests that environmental scientists may be a new breed of specialists creating a new scientific paradigm with research that might not be traditionally based as in other disciplines.

For this reason it is anticipated that an investigation of the journal citation patterns of environmental scientists will contribute to a better understanding of their scientific paradigm. Due to logistical limitations -- and the purpose of this study as stated in this chapter under "Problem Statement" -- this study narrowed its scope to cover only the investigation of the citation patterns of environmental scientists at the University of Massachusetts at Boston. Thus, it can be counted as one of the first prototype studies of this kind. This study will compare the citation patterns of environmental scientists and biologists at the University of Massachusetts at Boston (UMB) with the citation patterns of other scientists as they appeared in *Journal Citation Reports* (*JCR*), *Science Citation Index* (*SCI*).

The following information offers the fundamentals on what *JCR* does in journal citation analysis, followed by a description of UMB curriculum and research.

Journal Citation Reports

Journal Citation Reports (*JCR*) published by the Institute of Scientific Information

(ISI), is a "bibliometric analysis of science journals in the ISI database" (Institute of Scientific Information, 1989 p. 5A). This publication is part of *SCI*, which is a calendar year citation index "based on the principle that there is some meaningful relationship between one paper and some other that cites it and thus between the work of two authors or two groups of authors who published the papers". This citation index has been published bimonthly, since 1966[4], with a final cumulative annual edition to the following parts: *Source Index*, the *Citation Index*, and the *Permuterm Subject Index.*

At the end of the year *JCR* is published as a separate part of *SCI* covering more than 4,000 journals for a total of over 10 million citations[5] from the *Social Science Citation Index* and the *Arts and Humanities Citation Index. JCR* offers analytical data on the citation frequency of journals in the ISI database.

JCR is made up of six listings:

- ***Journal Rankings***, this list consists of seven sections: an alphabetical list of the science journals in *SCI* and *Current Contents*, another ISI product followed by five sections of journal ranked by different counts; and a final section of journals cited in the ISI's *Social Science Citation Index* database. *Journal Rankings* is essentially a list of journals cited in a year (e.g. 1988), including its citation frequency for previous years. Then, five parts of this list rank cited journals by total citations

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[4]The first issue of the ***Science Citation Index*** appeared in 1961. *JCR* officially started in 1971. Before this year, *JCR* was published separately and on an irregular basis.

[5]Figures for the 1992 edition, latest edition available as June of 1994.

for the last ten years in the database; second by impact factor; third by immediacy index; fourth by source items published in *JCR*'s current edition; and finally by the number of citations to articles cited and published in the preceding two years in any of the ISI source journals.

- ***Source Data Listing*** is an alphabetical list of ISI journals with the number of review and non-review articles published in each journal, including the number of citations received by each of the articles in these categories.
- ***Half-Life Listing*** offers chronological data on cited items in the database. It is subdivided in three parts: *Cumulative Chronological Distribution of Citations from Citing Journals*, *Cumulative Chronological Distribution of Citations to Cited Journals*, and *Journals Ranked by Cited Half-Life.*
- ***Subject Category Listing*** lists source journals and cited journals by specific disciplines, such as *Anatomy* and *Morphology*, journals are ranked by impact factor, and half-life data is included. The subject categories are defined by ISI, and
- ***Citing Journal Listing*** and ***Cited Journal Listing***, both include data on "citing journals" and cited journals. This listing also includes impact factors data, this is a ratio developed to compensate for differences in size, subject, and the publication frequency of journals.

These sections and listing, according to ISI, have distinctive functions that address

the following questions:

- How often is a particular journal cited?
- What journals have cited this particular journal?
- How frequently have other journals cited this particular journal?
- Is it old or new material being cited?
- What journals are cited by the authors publishing in this particular journal?
- How often do these authors cite these journals?, and
- What journals are cited more frequently in a specific discipline?

University of Massachusetts at Boston

The University of Massachusetts at Boston (UMB), one of the five campuses of the University of Massachusetts,[6] was founded in 1964 as a liberal arts college to serve the academic needs of the State's metropolitan area and inner-city population (Grasberg, 1989). Nowadays, UMB offers both professional and liberal arts programs at the graduate and undergraduate levels, its Doctoral and Masters programs focus on urban issues and problems. The research in the Environmental Sciences Program and the Biology Department, for example, includes water, coastal and marine contaminations; biochemistry; and genetic mutations (University of Massachusetts at Boston, 1993).

The total student body in 1992 was 6,950 full-time-equivalent (FTE) undergraduate

[6]The University of Massachusetts is the state university of the Commonwealth, founded in 1863 under the Morrill Land Grant Act passed by Congress in 1862.

students and 1,104 FTE graduate students, for a total student body count of 11,775. This university has an FTE faculty of 820. These are supported by a staff of 1,024 members (University of Massachusetts at Boston, 1992). The largest college at UMB is the College of Arts and Sciences.

College of Arts and Sciences

The College of Arts and Sciences (CAS) offers over thirty four undergraduate majors (University of Massachusetts at Boston, 1990), over twenty-three minors and twenty-two programs, and graduate programs at the doctoral level including Environmental Sciences and Environmental Biology (University of Massachusetts at Boston, 1991).

Specific scientific research interests related to environmental sciences and environmental biology at UMB-CAS includes, for example, microbial-biodegradation, aquatic toxicology, marine geochemistry, and phytoplankton. The external funding support for research at UMB totaled over twelve million dollars between 1988 and 1992 (*Science Newsbrief*, Numbers 2 to 9, 1992).

Definitions

The following definitions are given as they relate to the purpose of this study. *JCR* definitions are incorporated in this section, these are: citation, cited items, and other pertinent terms in this list.

Academic Scientist: One who teaches and conducts research in a scientific

discipline or a field such as Biology, Chemistry, or Mathematics.

Citation: When a document mentions or refers to another document, then the latter has been cited by the former as a source of information, as a support or debate for a specific point of view or datum, as authority for a statement of fact, etc. It is also used to indicate any description of a document contained in a reference or bibliography to a specific work. In this sense reference and citation are used interchangeably.

Citation analysis: A method of counting the number of times journals, etc., are cited in footnotes or bibliography in a source article, book, or any source document. Cited sources can be arranged in descending order of frequency of citation either by format, year, or type of publication. The terms employed to describe this method have evolved from statistical bibliography, to bibliometrics, to citation analysis. It is considered a valid method of looking at information use patterns. In addition to the mentioned variables, this method is useful for identifying cited forms of publication, age of publication, country of publication, language of publication, self-citation rate, author affiliation, and

frequently cited titles or sources.

Citation Index: An alphabetical list by author or other entry, of items cited in references from footnotes or bibliographies in a source article or document. The citation gives a description that identifies each item as unique.

Half-Life: The number of years going back from the current one, which accounts for half of the total citations received by the cited journal in that same year. It is also referred as the median age of cited journals.

Cited Journal: A journal cited by an author.

Isomorphic: Having the same form or construction, said of two sets of things, the parts and the structure of one corresponding to those of the other, having isomorphism. Having the same appearance.[7]

Science journal: Any scientific periodical issued with regular frequency which contains scholarly articles and disseminates current information on research and development.

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[7]***Funk and Wagnalls New Standard Dictionary of the English Language*** (1958). New York: Funk and Wagnalls Company.

Environmental Sciences in Universities and Colleges

The increased visibility of the Environmental Sciences field is not just an impression, there is evidence on its growing presence. For instance, the U.S. Environmental Protection Agency estimated that 3% of the GNP will be spent on environmental training and projects by the year 2,000. In 1992 the industry employed approximately 40,000 people in Massachusetts alone, it is expected that this number will increase to over 75,000 by 1994 (Allen, 1992). Subsequently, in response to the need for educational preparation, universities and colleges such as Lesley College, Wheelock College, Wentworth Institute of Technology, Massachusetts Institute of Technology, Northeastern University, and Simmons College in Boston are offering or developing environmental sciences B.S., M.S., and Ph.D. degrees. The growth of Environmental Sciences Programs has skyrocketed, for example, the aforementioned colleges began their environmental sciences programs in 1992 and 1993 (Ann Montgomery-Smith, Personal Communication, March 13, 1993), while the University of Massachusetts at Boston started the environmental sciences Ph.D. in 1982, and the M.S. in 1990, while the environmental biology Ph.D. started in 1992.

On the other hand, the creation of environmental sciences degree programs in colleges and universities has taken place amidst higher education funding cuts. It is also expected that the interdisciplinary nature of the environmental sciences should pose additional challenges for academic libraries with limited resources and growing responsibilities.

Background to the Problem

Whenever a new academic program is introduced it is expected that there will be a significant financial impact on various academic services in the University, including the library. Thus, with the creation and expansion of the Environmental Science Program and the Environmental Biology Track at the University of Massachusetts at Boston, the Joseph P. Healey Library has felt clearly this impact.

For example, in 1982 the Healey Library received "seed money" to support the new Environmental Sciences Ph.D. program and the journal budget for that program has been absorbed in the overall budget since then. The journal budget for environmental sciences totaled $79,896.08, over 10% of the 1993 periodicals budget of $782,294.00. Yet, when the Environmental Biology Ph.D. Track started in 1992, there was no additional allocation for additional library materials needed. The current periodical budget for the Biology Department in 1993 was $110,531.04, 14% of the total periodicals budget. Thus, when the Biology and Environmental Sciences journal budgets are combined, the total represents 24% of the library's overall periodicals budget, or 15% of the library collection budget including books and other non-journal materials. This is a substantial amount and given the current economic situation, it is unlikely to be increased in the near future.

On the other hand, as the typical journal cost increases for academic libraries at the estimated rate of 7.1% per year (EBSCO, 1995), the library's purchasing power decreases proportionally. This will seriously affect the library's ability to meet the faculty

and students' information needs. Clearly, there is a mandate for the Healey Library to find the most effective and productive ways to maintain and build its journal collection as well as to verify the effectiveness and efficiency of the current journal collection development.

Problem Statement

Against this background and the problems stated, the key question will be:

- What should be the basic journal collection for UMB environmental scientists and biologists?, and
- How to identify this collection?

In this study the citation analysis method -- to be elaborated in Chapters 2 and 3 -- will be used to address this question with the hope to obtain answers to the following:

- What publication forms do the UMB environmental scientists and biologists cite?
- What journals do they cite more frequently than others?
- How do their journal citation patterns of the UMB environmental scientists and biologists compare to those of other scientists?
- What is the half-life of the journals the UMB environmental scientists and biologists cite?
- Is the half-life of the journals they cite similar to those of other scientists?
- Do they cite journals from many subjects, and how frequently do they cite these?
- How does the citation frequency of the journals they cite compare to those of other scientists?

- How does the citation frequency of the journals they cite compare to those of other scientists (by subject category)?

It is hoped that the findings will provide a framework for collection development at Healey Library. It is also hoped that the study will provide some insights on the inter-disciplinary nature of the field. As discussed earlier, it seems that environmental scientists may be precursors of new scientific paradigms. If this is true, what effects will this have on libraries? Will this imply a different approach to collection development? On the other hand, the UMB environmental scientists and biologists may rely on the same sources of information that other scientists rely on. If so, are there any differences on journal citation scattering, age of cited items, and so forth? What does this imply for collection development in libraries? These are significant questions which deserve closer investigation.

Objectives, Research Questions, and Hypotheses

This study is guided by the forthcoming objectives, research questions, and hypotheses. Objectives 2 to 5 specifically are guided by the list of questions presented under "Problem Statement" in this chapter. Those research questions are not restated in this section to reduce repetition.

Objective 1 ***To identify the citation patterns of environmental scientists and biologists at UMB.***

Research Questions What publication forms do environmental scientists and biologists cite and how frequently?

What similarities and differences exist between the citation patterns of the environmental scientists and biologists?

What journals and subjects do the UMB environmental scientists and biologists cite more frequently?

Hypothesis There is an isomorphic relationship between the citation patterns of the UMB environmental scientists and biologists. In other words, the publication forms cited by both respectively and the citation frequency of these are similar for both groups of academic scientists.

Objective 2 ***To compare the rankings of the journals cited by the UMB environmental scientists and biologists with those in JCR.***

Hypothesis There is an isomorphic relationship between the rankings of the journals cited by the UMB environmental scientists and biologists and that of *JCR*.

In comparing the ranking order there is no statistically significant difference (at the 0.05 level) between the ranking order of the journals cited by the UMB environmental scientists and biologists and the ranking order of *JCR* journals.

Objective 3 ***To identify the half-life of journals cited by the UMB environmental scientists and biologists and compare it with that of JCR.***

Hypothesis There is an isomorphic relationship between the half-life data of journals cited by the UMB environmental scientists and biologists and that of *JCR*.

Objective 4 ***To compare the half-life data of journals cited by the UMB environmental scientists and biologists with that of JCR (by subject category).***

Hypothesis There is an isomorphic relationship between the half-life data of journals cited by the UMB environmental scientists and biologists and that of *JCR* (by subject category).

Objective 5 ***To compare the ranking order of journals cited by the UMB environmental scientists and biologists with that of JCR (by subject category).***

Hypothesis There is an isomorphic relationship between the ranking order of journals cited by the UMB environmental scientists and biologists and that of *JCR* (by subject category).

In comparing the ranking order of journals there is no statistically significant difference (at the 0.05 level) between the ranking order of *JCR* journals by impact factor (by subject category).

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Chapter 2

LITERATURE REVIEW

A review of the literature produced no studies on the citation patterns of environmental scientists. On the other hand, the literature review yielded several investigations on *JCR*, these are discussed in this chapter. In addition to these studies, this chapter covers aspects of scientists' search and use information, as it also cover aspects of their citation behavior. This is followed by a review of citation analysis in the hope that it will help the reader place this method in perspective. Finally, the last section of the chapter reviews studies in relation to this investigation as they provided directions in the assessment of the citation patterns of the scientists studied in this investigation.

Overview of Scientists' Seeking and Use of Information

Over the years, interest in scientists' search and use of information has produced several significant studies. Some of these studies focused on specific and different aspects of the information seeking behavior, as well as on the use of sources, and the informal and formal communication patterns of many scientists. For example, Voigt (1959) conducted a study of Scandinavian biologists, chemists, and physicists. He found that these scientists used various methods to access information, these were: browsing and reading, following recommendations of colleagues, personal contacts, the use of memory,

as well as the use of citations from books and journal articles, and finally, the use of indexes and abstracting services. From these findings Voigt was able to hypothesized that these information seeking patterns were related to three approaches, or information need levels that he labeled: the "current approach", the "everyday approach", and the "exhaustive approach".[8] Voigt also found that despite the variances in the information seeking patterns and use of journal literature among disciplines - as represented by the different scientists in his study - the "approaches" remained constant (Voigt, 1961).

Later, Hanson (1964), in a review of studies conducted to identify scientists' use of information, pointed out to the similarities between a group of studies and Voigt's findings. The studies reviewed by Hanson suggested that scientists in different disciplines seek and use information in similar ways, first, relying on personal contact, on journals, and on abstracting services, and so forth to be able to satisfy an information need. With this background Hanson was then able to identify the different methodologies used stressing and profiling the similarities of the findings in each study despite the differences in the disciplines and the scientists studied (i.e. physicists, chemists, etc.). The next year, Aims (1965) investigated Britain's physicists and chemists' information seeking and

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[8]The current approach refers to scientists' needs to keep abreast with the developments in their fields. Browsing, reading, and personal contacts play a major role in this information seeking pattern. On the other hand, bibliographic tools, such as indexes and abstracts, are of small importance at this need level. The everyday approach encompasses the need for specific data that arises in the scientist during work. Here, once again, personal communication ranks highly, while use of printed sources is less common. The exhaustive approach can be related to the current and everyday information needs. According to Voigt, this need arises when the scientist needs "all" information for a new investigation or publishing original research. It is at this level that bibliographic sources, especially abstracting services, can play a significant role.

information use, and described findings similar to those of Voigt.

Similarly, Barber (1966) pointed out that many of these studies have large quantitative discrepancies in their findings. She attempted to correlate the findings from twenty different user studies, but was unable to accomplish the task, concluding that methodological problems were responsible for the discrepancies between the studies.[9] In other words, Barber felt that each study was conducted without scientific stringency, using only scientists willing to cooperate, using case studies, or questionnaires, interviews, diaries, or a combination of these producing the disparities between the studies. Nevertheless, the emerging patterns were similar.

Later, Wood (1971) further analyzed user studies on scientists and concluded that academic scientists did make more use of formal communication channels (e.g. scientific journals, and abstracting services), than their colleagues in the industrial sector. Yet, communication with peers and other colleagues ranked first as the chief source of information for both groups of scientists. Furthermore, Wood pointed out that this reliance on the informal communication channels generally lead to the use of formal communication such as journals. Yet, according to Wood, the type of literature sought is not always the same and it varies by institutional affiliation of scientists, the scientists' discipline, and their academic degrees. Wood concluded that generally academic scientists sought, used, and referred to journals more frequently than any other group.

That same year, Lin, Garvey, and Nelson (1971) studied information flow in the

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[9]Please refer to Barber's article, pages 150 to 151 for a list of the studies she reviewed and assessed.

sciences and engineering. Their longitudinal study focused on the information exchange among scientists, starting with papers presented in meetings and conferences to the eventual publication of this papers on journals and the subsequent citations to these articles by other scientists. These three authors confirmed that scientists used a number of journals that are never cited in the final journal article. From this finding they concluded that scientists use a small number of journals central to the literature of the discipline and cited a fairly smaller number of journals in their publications.

Some years later, Chen (1974) conducted a study of physicists' information needs that confirmed the findings of the studies mentioned above. Her findings pointed out a difference in journal scanning, browsing, and reading, between those of other scientists and the scientists in her study. Chen noted that new selective dissemination of information (SDI) services, in addition to the availability of new current awareness services and publications, may explain most of the differences found. Finally, according to Chen's findings, journals continue to be the primary source for formal communication.

The studies previously discussed, as well as other studies were reviewed by Garvey (1979) who also analyzed the communication process of science. In his book Garvey pointed out that journals ranked first for formal communication among scientists, representing the most important information exchange vehicle. According to Garvey, scientists rely on journals for conducting their research, for gaining and maintaining visibility among their peers. In addition, scientific journals are the one public medium to establish expert status. However, more than tools of visibility, journals are the major medium for recording knowledge, and for this reason they receive such emphasis in

libraries.

As shown, scientists rely on journals as a formal means of communication to report and learn about advances in science. However, the degree of reliance on journals varies by scientists' affiliation (e.g., academic or industry affiliation), by requirements in the work place, and by personal factors as well.

Besides the studies discussed, other studies have focused on other aspects of scientists' communications such as peer interactions. For example, Hagstrom (1965) found a strong positive correlation between performance and extra-organizational communication in academic disciplines. In other words, scientists that used external information sources were more productive than those who did not. On the other hand, Allen and Cohen (1969) found information "gatekeepers" in two R&D laboratories. In this case, these gatekeepers either had a Ph.D. or occupied a managerial position in the laboratories, thus information seeking between peers and staff in these laboratories was closely related to the organizational chart or to the academic standing of scientists in the laboratory.

Yet, according to Krikelas (1987), user studies -- such as the ones discussed -- can be expanded by including bibliometric studies. Citations, particularly, have been used by numerous studies. However, the reasons why scientists cite are a source of controversy.

Scientists' information seeking behavior and citation patterns to this day continue to be areas of investigation. Many studies have found similarities to those studies previously discussed in this chapter. For example, Hallmark (1994) found that personal contact between scientists continued to be the chief source of guidance when seeking for

information. She also found that the scientists in her study counted on libraries as the chief information-source providers. In other words, the physicists, chemists, biologists, mathematicians, and geologists in her study counted on libraries over 50% of the times to find needed journals, while their reliance on reprints, and photocopies from colleagues was much lower, ranging from 39% to as low as 12%.

Overview of Scientists' Citation Behavior

When a scientist cites or refers to a source in his publications it would be difficult to believe that he or she does so in a attempt to influence collection development in libraries. Therefore, it can be assumed that scientists cite and reference their writings for quite different reasons. For example, Weinstock (1971) discussed the following uses of citations:

- Paying homage to pioneers;
- Giving credit for related work;
- Identifying methodology, equipment, etc.;
- Providing background reading;
- Correcting one's own work;
- Correcting the work of others;
- Criticizing previous work;
- Substantiating claims;
- Alerting researchers to forthcoming work;
- Providing leads to poorly disseminated, poorly indexed, or uncited work;
- Authenticating data and classes of fact;
- Identifying original publications in which the concept or idea was discussed;
- Identifying original publications describing an eponymic concept or term;
- Disclaiming works or ideas of others; and
- Disputing priority claims of others.

Scientists' citations have been used by information managers, sociologists, and scientists for research. This has launched many debates, concerns, and conflicting theories on why these cite. For example, Garvey (1979, p. 84-85) in discussing the value of citations and their role in understanding scientific communication, said that:

> Our present knowledge of citing behavior in scientific journals is so little understood that it is not clear how much citing is done because of the relationship of citations to the structure of scientific knowledge or how much because an author is trying to infix his article in a particular stream associated with a journal. In any event, an author will be better off if he makes certain he has cited all relevant articles published in the journal to which he is submitting his manuscript than concentrating on citation outside the stream of that journal. This is not to say that a scholarly journal should not cite all pertinent publications, but in practice a particular journal's editorial group will be more likely to detect missing citations previously published in its journal.

Later, citation analysis was thoroughly reexamined by Cronin (1984). He discussed the role of citations in science as another example of the complexity of scientific communication. According to this author, citations are used and occur in contexts which are due to certain and unknown conditions inseparable from the authors intentions, the social processes of science, and the pressures and possible constrains associated with the construction and dissemination of knowledge. In addition, Cronin said that citations are governed by a universal set of norms and personal considerations which are extremely complicated and difficult to grasp. He also believes that trying to seek for an integrated and "uni-dimensional" theory to explain citation behavior is highly unrealistic. It was Thorne (1977, p. 1161) who indicated that authors use citations as stratagems, as it can be seen these reasons exceed those of Weinstock. Thorne's list is:

- Serial publication (division of a single research into many parts, each reported separately);

- Multiple publications (minor variations of a project report submitted to different journals);
- Hat-tipping citation (acknowledgement of eminent figures);
- Over-detailed citations;
- Over-elaborate reporting;
- Evidentiary validity (citations can be selected to support any point of view);
- Self-serving citations;
- Deliberate premeditation (conscious playing of the citation game);
- Searching out grant funding (identifying currently popular citation trends);
- Funding support for publications (the publication of luxurious research reports to attract attention);
- Editorial preferences (authors seek to identify preferred topics and styles to journals to which they submit);
- Citations as projective behaviors (citations as reflection of authors biases);
- Conspirational cross-referencing (the you scratch my back and I'll scratch yours syndrome applied to citation);
- Pandering to pressures (citing works because it is felt that the reading public requires, or expects them to be cited);
- Editorial publication policies (discriminatory biases in editorial policies re. selection and rejection);
- Non-recognition of new authors;
- Intra-professional feuding;
- Obsolete citations; and
- Political considerations (citing the "party line").

Debates on citation analysis continue to this day. For example, Leydesdorff and Amsterdamska (1990) concluded that the differences and difficulties with citation theories, as well as the multidimensional character of citations, and the complexity in citation behavior still seem to leave unanswered the "Why do scientists cite?" question.

Based on these discussions it can be stressed that the context in which citations are used is extremely complex. This complexity has interested several authors that created lists of indicators to assess and try to identify scientists' intentions when they cite a source. For example, Lipetz (1965), Duncan (1981), Frost (1979), and Peritz (1983)

have proposed several additional schemes for analyzing citations including content related citation studies. Despite the controversies citations remain as legitimate objects for research (Peritz, 1992).

The citation behavior and the citation patterns of scientists and scholars continued to be studied in many ways over the years. For example, Peters and Van Raan (1994) have studied the factor influencing citations. In their study they found that two factors were related to the citations that internationally renowned chemical engineering scientists received. These factors are the number of publications made by the renowned authors and the number of citations included by the authors citing the papers of these well-known chemical engineers.

Citation Analysis

Citations can be investigated for different objectives. For example, to identify trends in the age of materials used, to study the characteristics of the literature in a subject or discipline, also to investigate scholarly communication, and for the development of collections in libraries and information centers (Subramanyan, 1980). In discussing the value of citation analysis Cronin (1984, p. 25) said that:

> Metaphorically speaking, citations are frozen footprints on the landscape of scholarly achievement; footprints which bear witness to the passage of ideals. From footprints it is possible to deduce directions; from the configuration and depth of the imprints it should be possible to construct a picture of those who have passed by, whilst the distribution and variety furnish clues as to whether the advance was orderly and purposive. So it is with citations in respect to growth and development of scientific knowledge; they give substantive expression to the process of innovation,

> and, if properly marshalled, can provide the researcher with an analytical tool of seductive power and versatility.

This method, according to Subramanyan (1980), fundamentally consists of counting the footnote references or bibliographies in any publications. Then these are arranged in some order, for example, by descending citation frequency of the items counted from the source publications that include books, journals, and any other sources. This enables the researcher to study the communication patterns of scholars and authors (Baker, 1990). In this sense, according to Martyn (1975, p. 290), citation analysis is:

> ...it is the study or analysis of the citations or references which form part of the scholarly apparatus of primary communication. ... [The method is] ... largely used for putting things in order. The things ordered can be journals, papers in journals, authors of papers in journals, or organizations to which authors of journals are affiliated. The type of ordering can be linear, as in ranking, or multidimensional, as in the generation of citation networks. Studies of obsolescence rates of journals or documents may be considered to be special cases of rankings, over time. Whatever the type of analysis performed, the interpretation of the results hinges on the nature of the relationship between the citing and the cited documents.

Like any methodology, citation analysis operates under certain assumptions. First, citations are generally accepted as some undefined measure of use of materials. This as discussed by Martyn (1975, p. 291), might mean "readership" or perhaps "borrowing frequency". Yet, Martyn noted that still there is no clear evidence that citation frequency correlates with any use measure. It can be said that a citation is a measurable and quantifiable unit that represents some expression of a relationship of yet undetermined significance between two documents. Then, it is necessary to assume that all citations are units that have equal value. Consequently, these assumptions leave little margin for evaluating why a citation was used.

Yet, despite all these limitations, citation analysis is considered a valid and useful research method, but, it should not be used in isolation in case of journal deselection studies. Generally, citation analysis findings and their interpretation must bear in mind that authors tend to cite publications that become known and are readily available to them. This, as well as other physical barriers (e.g., lack of foreign language skills), may affect the citing behavior of authors and the relationship between the citing document and the cited source.

To this day citation analysis continues to be a frequently used methodology. For example, Dumas, Logan and Finley (1993) studied citations to determine growth ratios and trends within different disciplines. They divided the citations by several categories, such as "methodology", "theory and practice", and "related fields". Then they analyzed the different categories to determine foci and trends with in the fields in their study. Another new use of citation analysis was developed by Soehner, et al. (1992) that identifies "landmark authors" and the citations that these authors receive. Then, with this data a bibliography is created. This bibliography becomes a collection evaluation tool for a library that wants to assess its holdings in a specific and narrow subject like environmental microbiology. At the same time, these authors claim, that this method can show the interdisciplinary use of citations by scientists in different fields.

Journal Citation Reports

ISI uses the theoretical background just discussed to create *SCI* and other citation

indexes. For obvious reasons the assumption that some meaningful relationship exists between the citing and the cited journal has proved to be a useful way of retrieving citation information related to particular authors or journals. This convenience is also the basis of the function performed by *JCR*, which is unique for journal citation analysis. For logistical reasons the data offered by *JCR* and *SCI* could not be retrieved without considerable effort and time.

Based on this value, Eugene Garfield -- former Editor in Chief of ISI -- strongly proposes *JCR* as one of the most valuable sources of data available for journal collection development. Furthermore, he said that *JCR* data may be the most reliable indicator of a journal's subject area and that *JCR* "offers objective evidence of the optimum makeup of a general and special journal collection". (Institute of Scientific Information, 1989, p. 8A).

Contrary to Garfield's statements, Garvey (1979) believes that *JCR* data might be skewed by interference in the citation process, where the "noise" might dominate the message. In other words, Garvey is concerned about possible inaccuracies occurring in citations as a result of the hidden personal factors listed by Thorne (1977) and the absence of a sound empirical background.

On the other hand, other researchers and authors feel that *JCR* is as good as local journal in-house studies. For example, Broadus (1985), a vehement proponent for the use of citation data for journal deselection, indicates that *JCR* can be almost as good as expensive local studies for predicting the use of periodicals in a library. Other followers of this trend are Subramanyan (1980) who is inclined towards the use of *JCR* as a journal

deselection tool, and Dombrowski (1988) who recommends *JCR* based on the assumption that the "national list" will provide an accurate indicator of local ranking.

JCR and Collection Development

These favorable recommendations on *JCR* have found fertile ground in many librarians who were conducting journal deselection studies and used *JCR* data in different ways. For example, *JCR* impact factors data has been used in several studies that incorporated it with other factors as means to assess the worth of one journal over another. On the other hand, in some cases, librarians cancelled all journals not included in *JCR* or have decided to exclude it as they feel it is not representative of their collections.

The use of *JCR* data for journal collection development has been studied and debated. In a summary of *JCR* use, Kraft (1979) reviewed the literature of journal deselection, and strongly advocates the use of *JCR* data for determining journal worth. Another more recent author, Miller (1990) developed a journal worth formula using *JCR* data as an "effectiveness factor", favoring the use of *JCR* for journal deselection.

On the other hand, some studies suggest that the citation data does not necessarily apply to all environments. For example, Swigger and Wilkes (1991) believe that *JCR* data are not comparable to any use measure (e.g., in-house use). Some of the studies that used *JCR* data as a criterion in the deselection process have correlated their local rankings of journals with those in *JCR*. The findings of such studies are discussed in the following

section of this chapter.

Some conflicting evidence between local journal use rankings and that of *JCR* has been found. For example, Bensman (1985) analyzed Interlibrary-Loans (ILL), in-house use, and journal circulation. When he correlated the rankings of journals from these different methods, he found a correlation of low significance between these and *JCR*. However, faculty's journal requests were found to correlate highly with *JCR* data.

On the other hand, Bostic (1985) devised a formula to determine the worth of journals, this formula incorporated *JCR* impact factors, and it combined use data, "relevance", and other factors. Bostic claims that the *JCR* rankings are valid for determining the worth of a journal. Based on her findings she recommends the deselection of journals not included in *JCR*. Yet, another researcher, Broude (1978) developed a journal deselection model incorporating several factors, including *JCR* data. After the model was applied, faculty input was sought to rank the journals under study. To the researcher's surprise, no correlation was found between the model's suggested titles for cancellation and faculty choices. Furthermore, faculty choices were found to have a low correlation with *JCR* data supporting differences between local data and that of *JCR*.

Before these studies, Pan (1978) correlated *JCR* journal rankings with the rankings of journals used in ILL, in-house use, and circulating out of the library, she found some correlation between these and those of *JCR*. Another study that found correlation between local journal use data and JCR was conducted by Scales (1976). In this study the National Lending Library (NLL), ILL data was compared to data of three lists of

journals ranked by citation frequency, including *JCR*. She found little correlation between NLL rankings and those of *JCR*.

The next year, Rice (1979) ranked in-house use of science journals at SUNY-Albany. When these "journal rankings" were correlated with those of *JCR*, she found very weak correlations. Later, Stankus and Rice (1987) revised the findings of Rice's 1979 study by grouping the journals by subject. They found a good correlation between in-house use data and *JCR* ranking of journals by impact factor in the studied subject categories. In addition, to the rank correlation, these investigators tabulated their findings for isomorphic comparison.

Later, Wiberly (1982) found weak correlations between the citation rankings of social work journals and those of *JCR/SSCI*. Wiberly pointed out that *JCR* might not be an effective tool for journal collection development. On the other hand, Smith (1985), a strong proponent for indiscriminate use of this source, ignored all conflicting data and canceled all science journals not included in the *JCR*.

As shown, *JCR* data has been used in deselection studies, either as a single criterion or as an additional factor combined with other measures to assess journal worth. Other studies compared local use data of journals with that of *JCR* indicating discrepancies and similarities between both.

Overall, these studies suggest that *JCR* data and journal use data of specific libraries does not always correlate. A question arises: Is *JCR* data good for collection development for libraries?, and, Is there another method to compare local journal rankings with those of *JCR*? This last question was addressed by Baughman (1974). He did a

citation analysis of sociology literature and found an isomorphic resemblance between the citation data in his study and use data of other studies on that discipline.

As mentioned earlier in this chapter, no studies were found that revealed any data on environmental scientists' citation patterns. Therefore, the discussion that follows covers areas that are expected to be pertinent to the environmental sciences but peripheral to the possible core subjects of this field. This section is included with the hope that it will show scientists' interdisciplinary reliance on journals while it presents relevant findings related to the study population of this investigation.

From these studies Kelland (1990) deserves special attention as he compared the citation patterns of scientists in environmental biology (ecology) and biochemistry. In his study he focused on 1986 source publications taken from *Biological Abstracts*' Biochemistry and Ecology subject categories. Kelland found few and small discrepancies between the citation patterns of these scientists either by age, by subject or type of publications cited.

In an earlier study, Sengupta (1973) conducted a citation analysis study to determine the best journals for biochemistry collections. His findings showed that biochemists primarily cited: journals (86.4%), other serials (4.7%), and non-serial publications (8.9%). Of this last group, 4.2% were to books or monographs. Sengupta also found that English was the primary language of communication and that biochemists cited different journals under several subject categories. Then, in further handling of the data, journals were ranked and grouped by subject category, it was found that the Multidisciplinary subject category yielded the most citations. Overall, journals published

by scientific associations yield the highest number of cited items.

Another study that examined a peripheral area was conducted by Freeman (1974), who examined the literature of marine biology using citation analysis. In his study he focused on age, language, and journals cited by marine biologists. Although Freeman did not compare his findings to *JCR* an examination of his findings shows that his list of journals resembles *JCR*'s Marine and Freshwater Biology subject category list -- supporting isomorphic comparisons.

Investigations of the journal citation patterns of academic scientists, and graduate students, showed that despite the difference in the studied populations, journals continued to be the most cited publication form. For example, McCain and Bobick (1981) found that academic biologists, (i.e., graduate students, Ph.D. candidates, and faculty) at Temple University cited the same journals but that the rankings were different among the studied groups, yet the rankings did correlate. Like many other authors they feel that actual citation patterns are effective to forecast future citation patterns as authors rely on the same cited journals again.

The studies discussed in this last section suggest possible avenues for conducting research. These also point out to conflicts and similarities between their data and that of *JCR*. It is hoped that this discussion shares light on and supports this investigation's framework. In other words, the studies conducted by Pan (1978), Stankus and Rice (1987), Wiberly (1982), and Baughman (1974). suggested subject correlation and isomorphic comparison as means of assessing the local journal citation patterns with those of *JCR*.

More recently, a few studies have assessed *JCR* and the citation patterns of scientists. For example, Harmon (1992) studied the citation patterns of the 40 most cited science theorists and found that the papers published by these theorists conformed to publication style of experimental and methods papers, yet the contents differed substantially. He also found that there was a relationship between the journals were the citing authors published, the journals were the articled cited was published, and the *JCR* ranking data.

In addition to this discussion this chapter examined scientists information seeking behavior, information use patterns, and citation behavior. Citation analysis was discussed and its usefulness as a research tool was assessed.

The following chapter presents the advantages, limitations, and assumptions related to this method and this study.

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Chapter 3

STUDY PROCEDURE

This researcher selected citation analysis as this study's methodology. This method is considered the most suited when compared to other methods such as in-house use of publications, circulation statistics, interviews, and/or questionnaires. In discussing the advantages and disadvantages of research methods Baker (1990), Hernon (1989), Hernon and McClure (1990) and Lancaster (1988) presented the following advantages of citation analysis:

- unobtrusive;
- minimal or no cooperation required from study population; and
- facilitates focus in specific study populations.

Advantages and disadvantages of citation analysis method are presented in Figure 3-1:

Figure 3-1

Advantages and Disadvantages of Citation Analysis [10]

Advantages	Disadvantages
• Measures the "use" of information resources by the citing authors;	• It is not certain that all materials used are cited, use of material can be underestimated;
• Measures research activity;	• It is not certain that all material cited were used, use of material can be overestimated;
• Has value as a predictor of future citation;	• External and internal factors that may influence citation patterns are hidden to the researcher;
• Provides a measure of an author or group citation activities and patterns;	• Factors such as: journal size, article length, and publishing frequency, in addition to time periods, and the type of publication, may have an influence on citation frequency;
	• Citation data is difficult to interpret and apply;
• Provides a profile of the literature used in the research process in individual fields;	• Inconsistencies and errors in bibliographic citations present problems in data collection and analysis; and
• Can determine the characteristics of materials used in a specific field;	• Information resources used are those available to the authors. Availability of materials is expected to be directly linked to citation patterns.
• Can reveal trends within a discipline;	
• Can be used to identify subject dispersion;	
• Can identify the status of research activities of scientists in specific countries, in specific fields, or in specific institutions; and	
• Can help libraries to design services and develop collections by identifying highly cited sources.	

[10]These advantages and disadvantages are discussed by many authors such as, Baker (1990), Broadus (1977, 1985), Cronin (1984), Festinger (1985), Frost (1953), Frost (1979), Garvey (1979), Leydesdorff and Amsterdamska (1990), Martyn (1975), Moed (1989), Peritz (1992) Price (1970), and Subramanyan (1980). Parts of this table are drawn from these authors.

Therefore, citation analysis is far more advantageous than any other research methods considered for this study. Figure 3-2 presents the disadvantages of the alternate methods considered for this study. Clearly, citation analysis advantages outweighs its disadvantages and the disadvantages of the other methodologies in Figure 3-2.

Figure 3-2

Disadvantages of
In-house Use, Circulation Statistics, Questionnaires and Interviews Methodologies [11]

In-house use Disadvantages	Circulation Statistics Disadvantages	Questionnaires and Interviews Disadvantages
• Labor intensive;	• Only measures use of circulating materials;	• Labor intensive;
• Obtrusive;	• Journals generally do not circulate;	• Require training and skills;
• Difficult to assess use of specific populations;	• Library automated system may not be flexible to produced desired reports; and	• Requires cooperation from study population;
• Requires cooperation from study populations; and	• If the library is not automated data collection is labor intensive.	• May yield low response rates; and
• Difficult to conduct with open stacks.		• Respondents must remember accurately and have to be honest.

All of these considerations lead to the selection of citation analysis as the preferred research methodology over the different options considered for this study.

Study Population

After selecting citation analysis as the research method this researcher had to

[11]Lancaster (1977), Hernon and McClure (1990), and Hernon et al. (1989) discussed the advantages and disadvantages of each of these methods.

decide on what population to focus on in order to maxime the benefit to Healey Library (HL) operations. The faculty of the UMB Environmental Sciences Program and the Biology Department were selected as the study population. There are several reasons for this decision.

- Like all academic fields , this faculty is required to conduct research and publish for their contract renewals, promotions, and tenure decisions;
- Students are expected to produce two major works: a publishable article and a dissertation or thesis;
- The faculty are also expected to be a long-term client of HL. This means that use of journal collection is an expected activity.

This researcher then narrowed the study population exclusively to full-time active faculty members in the UMB Environmental Sciences Program and the Biology Department. Thus, graduate students, former faculty, emeritus and adjunct faculty were excluded from the study.

To start with the study a roster with full names of the UMB Environmental Sciences Program, and Biology Department faculty was used to draw the names of study population. The whole list included a total of 34 FTE active faculty members. Nine of these 34 associated with the UMB Environmental Sciences Program and 25 of these were at the UMB Biology Department that satisfied the requirements imposed by this researcher.

Data Collection

Beyond the initial selection steps just described, additional steps were required to conduct the study. These were guided by the study objectives, research questions, and hypotheses stated in Chapter 1. The next new step was data collection, deciding how

source items should be retrieved and how the data would be handled.

Online Searching and Data Entry

After some deliberation, online searching was selected to retrieve the source items or publications, these included:

- book and book chapters;
- journal articles;
- conference proceedings papers; and
- technical reports.

Online searching took place between May and June of 1993. The source items to be retrieved from the search were published between 1988 and the spring of 1993, no additional sampling was devised to guarantee inclusion of all source items from the study population avoiding any misrepresentation. The online search was done in over twenty databases:

- Analytical Abstracts
- APILIT
- APITAT
- APTIC
- Aquaculture
- Aquatic Sciences and Fisheries Abstracts
- Biosis
- Biotechnology Abstracts
- Books in Print
- CA Search
- CHEMSEARCH
- Conference Paper Index
- Enviroline
- Environmental Bibliography
- Life Sciences Collection
- Medline
- NTIS
- Oceanic Abstracts
- Pollution Abstracts
- SciSearch
- TOXLINE
- Water Resources Abstracts
- WATERNET

- Zoological Record Online.

After the online search was conducted all duplicate records were examined and eliminated.

Online database searching was selected as the source item collection method because free searching was available at the time of the study. However, online searching is not without problems. For example, many databases vary in format, and:

- authors are included with name variations;
- all authors' institutional affiliations are not included;
- not all publication forms are included in one database; and
- extensive searching is required in several databases.

Nevertheless, it was felt that the quick retrieval advantages of online searching outweighed the disadvantages, especially when compared to other retrieval procedures such as manual searching. This last method was eliminated because it is time consuming and the retrieval obstacles are very similar to those in online searching.

Another method considered was a list of publications or curriculum vita requested directly to faculty. This was discarded as the study population showed some reluctance to give their updated curriculum vitae. In most cases this request required them to update their vita, or, in other cases, faculty was under peer review at the time of the study and it was felt that the review process required confidentiality.

From the online search 154 source items were retrieved. Immediately a group of criteria were necessary for data entry. This were:

- incomplete and unclear citations were eliminated;
- incorrectly abbreviated, thus, unidentifiable titles were eliminated; and

- full title of cited items was entered in the data collection form and into the database.[12]

Then, to obtain copies of the source items, this researcher used HL's science journal collection, other libraries in the Boston area, and interlibrary loan services.

Source Items

As said before the publications from UMB environmental scientists and biologists were the source items used to extract the citations for the study, the investigator decided to use source items from 1988 on, the year the first UMB environmental science Ph.D. dissertation was completed, and conclude with the source items available in late Spring of 1993, and as close as possible to the short time of free online searching available to this researcher.

Data Collection Form and Data Entry Reliability

To facilitate data collection, and keep control over this process, a data collection form was developed (see Appendix A), pretested, and tested for reliability.

To attain reliability this researcher required the participation of two librarians[13] for comments and suggestions. First, the librarians reviewed the form for accuracy and completeness in relationship to the study objectives, research questions, and hypotheses, no problems were found. This was followed by a pretest of the data collection form. For

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[12]This researcher used: ***World List of Scientific Periodicals***. London: Butterworths.; ***Periodical Titles: Abbreviation by Abbreviations***. Detroit: Gale Research Company. ***Ulrich's International Periodical Directory***. New Providence, NJ: R.R. Bowker; and ***Acronym, Initialism & Abbreviations Dictionary***. Detroit: Gale Research Company.

[13]Each librarian examined the data collection form, participated in the pre-test, test and data input examination separately.

this reliability check, twenty-five citations were randomly selected from each year and entered in the data collection form. Once the data was entered in the forms, the participating librarians reviewed each completed data form for accuracy; no errors, omissions, or discrepancies were detected. After this, data input process was tested and arranged to avoid inaccuracies. To check the data input process the participating librarians made random checks on the accuracy and correctness of the data entered in the database. This researcher printed the records for this test and checked these against the data collected in the form. All of these procedures served as reliability checks.

To compile the citation data each full unabbreviated citation was entered in the database designed by this researcher using Paradox. Paradox is a microcomputer-based relational database management software that allows descriptive statistical analysis. The design of the database was done with all the study variables in mind. This software package enabled this investigator to organize the data by different queries to produce tables by publication form, rank, subject category, and half-life, all in accordance to the objectives of the study.

To complete the data collection form and be able to do the rank correlation and isomorphic comparison it was required to collect data from *JCR*. This was collected from the *Cited Journal Listing*, the *Journals Ranked by Times Cited Listing*, the *Subject Category Listing of Journals*, the *Cited Half-Life Listing*, and *Journals Ranked by Subject Category*. It is necessary to point out that since 1989 *JCR* has been published in microform only, and that *JCR* is not available online. It is also mandatory to indicate that the 1992 edition of *JCR* was not available to this researcher until early 1994.

Half-Life

To complete Objectives 3 and 4 the half-life of journals cited by the UMB environmental scientists and biologists were hand calculated using the *JCR* half-life formula[14]. This required one additional logistics-related decision to handle the half-life data, this researcher decided to calculate only the half-life decimal of those journals cited ten times or more and then this data was entered in the database.

Isomorphism

To complete the isomorphic objectives of the study it was necessary to set operational procedures to deal with the isomorphic test. First, the calendar-year table of the rankings of the journals cited by the study population were divided in quartiles -- a procedure followed with the *JCR* rankings of the cited journals. Rankings were considered to be isomorphic with those of *JCR* if it fell in the same quartile in both tables and if the rankings position only varied by ±20 in that quartile. The second condition imposed was that at least 60% of the rankings had to meet the requirements described above.

A second operational definition of isomorphism for half-life data was established. Isomorphic half-life was defined to be a variation of ±1 between the half-life data of the

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[14]To obtain the half-life requires to calculate the half-life integer. This requires to count back form the citing year to the whole year before ≥50% of the total citations is reached. The half-life decimal equals the fraction of a year still needed to reach 50% of the citations. The decimal is calculated by subtracting the percentage reached before the 50% mark from 50%. Second, subtract the percentage reached before the ≥50%. The first result is divided by the second result. This result is truncated to the nearest tenth. Then the integer value is added to the decimal value. *JCR* does not calculate half-life to journals cited less than a 100 times in a year, nor those it offer half-life data beyond the last ten years.

journals cited by the UMB environmental scientists and biologists and that of *JCR*. This definition was applied to both tests in the study -- across-the-board, and by subject category.

Statistical Analysis of Data

The correlation hypotheses in the study were tested using Spearman's Rank Correlation Coefficient, this nonparametric test is concerned with the order relations of naturally occurring ordinal ranks that was develop by Spearman in 1904[15]. This test is used to determine the relationship between different rankings. The applied significance level for this study is 0.05 (Meddis, 1975; Chou, 1979; Siegel, 1956; Festinger and Katz, 1953; Healey, 1984).

To conduct the rank correlation test the researcher decided to use a microcomputer-based statistical analysis software package. The statistical package selected was Systat. This software package was readily available to this researcher, in addition, it could handle large number of sets, as well as it could handle large variations in the size of rank figures (i.e., 20 paired with 3,221) as those found in this study.[16]

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[15]Jerrold H. Zar developed a list of critical values of the Spearman's rank correlation coefficient for two and one tailed probabilities. However, the maximum *N* is 100. Further search in the mathematics literature did not provide a table that offered critical values for more than 100 cases.

[16]**Systat** is a comprehensive statistical analysis system produced by Systat Inc. in Evanston, IL.

Study Limitations

This study, as any other investigation, has several assumptions and limitations. These are summarized in Figure 3-3. The limitations of citation analysis as a research methodology as experienced and expressed by other researchers were presented in Chapter 2 and are summarized in Figure 3-1 and 3-3.

Figure 3-3

Study Assumptions and Limitations

Assumptions	Limitations
• Current and past citation patterns are assumed to reflect future citation trends;	• Findings interpretation and significance can not be extrapolated to institutions with profiles similar to UMB or be valid for the environmental scientists and biologists in general;
• Citation behavior at UMB is similar to the citation behavior of other scientists;	• The Environmental Sciences Program and the Environmental Biology Track at UMB focus on urban harbors and coastlines, including, but not limited to, sedimentology, oceanography, and aquatic toxicology;
• Communication patterns at UMB are similar to the communication patterns elsewhere;	• This study only focuses on faculty citation patterns, other UMB constituencies are not included in the study;
• Current citation patterns can forecast future citation patterns;	• The citation patterns of UMB environmental scientists and biologists may be different from the citation patterns of other environmental scientists in other institutions or conducting field research in other areas or focused in other environmental problems or issues; and
• *JCR* represents "normal science"; and	
• Cited items are a reflection of future demand or need.	• This study compares UMB citation frequency ranks with *JCR* subject category ranks by impact factor. These might be two different measures.

These limitations and assumptions raise concerns regarding the findings and their interpretation. Nevertheless, the limitations of this method do not undermine its value and its usefulness for identifying and assessing cited publication forms, citation frequency of materials in a library, as of those cited but not owned by a particular library. This method can yield valuable information to help identify core cited resources. Thus, it is expected that this proposed study yields useful information to Healey Library.

In addition, there are further limitations related to the selected population for the study, which focuses on the scientists of the Environmental Sciences Program and Environmental Biology Track at UMB. These are rather specialized programs whose curriculum and research narrowly focuses on coastal zone of urban harbors and shorelines as related to man-made problems. Thus, the types and titles of journal publication cited may differ sufficiently from those cited by scientists with more general subject interests. Therefore, this is a one-location study with results likely not generalizable, but essential for the Healey Library at UMB.

Finally, the reliance on journals for teaching cannot be assessed by this study. Academic scientists, in many cases teach students at all levels -- undergraduate, master and doctoral students. The significance of journals and other publication for teaching at these different levels might vary (Krikelas, 1987, Taylor 1990).

The findings and implications presented in the next chapters will be discussed in the light of the literature reviewed in Chapter 2, and the limitations and the assumptions presented in this Chapter.

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Chapter 4

PRESENTATION OF THE FINDINGS

The online search retrieved 154 source items. As shown on Figure 4-1, 151 were journal articles and three were books or book chapters. From these, three conference proceedings and one article contained no citations, thus they were eliminated. The 149 usable source items yielded 5,348 citations, of these nine citations were incomplete or incorrect and could not be included in the study. All the source items were retrieved through interlibrary loan services, by using the Healey Library (HL), by using other libraries in the Boston area, or by commercial document delivery services.

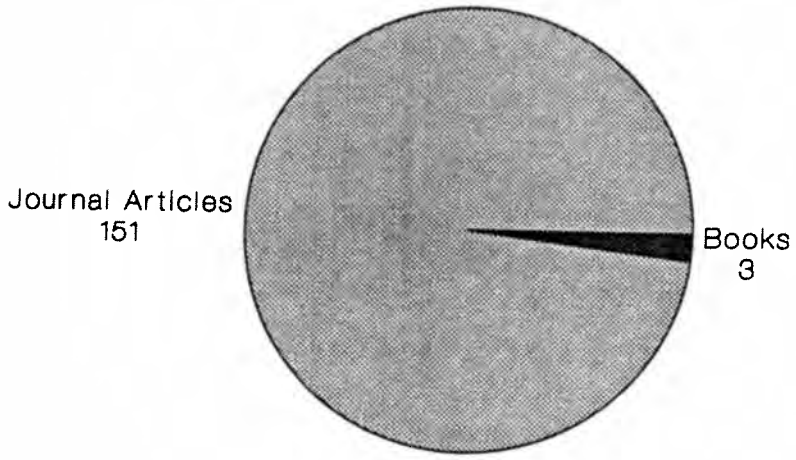
All the citation data from the source items and *JCR*'s data were entered in the Data Collection Form. These data were then keyed into the database designed for the study. The source items yielded the following number of usable citations:

Publication Forms	Number of Citations	Percentage
• Journal articles	4,554	85.30
• Books/book chapters	542	10.15
• Proceedings	118	2.21
• Reports	44	.82
• Dissertations	29	.54
• Unpublished items	45	.85
• Other	7	.13
• Total	5,339	100.00

The citations were handled accordingly to the objectives, research questions, and hypotheses of the study as stated in Chapter 1 and following the procedures detailed on Chapter 3. To facilitate the presentation of the findings the rest of this chapter is organized by those objectives, research question, and hypotheses. In most cases, the data are presented in tabular and/or graphic forms with easily understood format. No attempt is made to discuss the findings in great detail under the "Objective" heading since more detailed discussion on these findings follows after the initial presentations in the "Discussion" section. The implications of the findings will be elaborated on Chapter 5.

Figure 4-1

Source Items



Objective 1 ***To identify the citation patterns of environmental scientists and biologists at UMB.***

Research Question **What publication forms do the UMB environmental scientist and biologists cite?**

As shown in Figure 4-2 and 4-3, from 1988 to 1993, the UMB environmental scientists and biologists cited different publication forms and unpublished materials (see Appendix B for a list of definitions). These are:

- journals;
- books and book chapters;
- conference proceedings;
- reports;
- dissertations;
- unpublished sources; and
- other publications forms.

Table 4-1 shows the number of citations by publication form, and the percentage for each form for the two groups of academic scientists separately. The last column of the table lists the totals for the study population.

Research Question **What publication form do environmental scientists and biologists cite more frequently?**

As shown in Table 4-1, journals were the most frequently cited form of publication, representing 85.29% of the total number of citations. These were followed by books representing 10.15% of the citations, a far distant second. Conference proceedings occupy the third place in the citation frequency in both groups with 2.2% of the citations

Figure 4-2

Citation Retrieved From UMB Environmental Scientists and Biologists by Publication Form

1988 to 1993

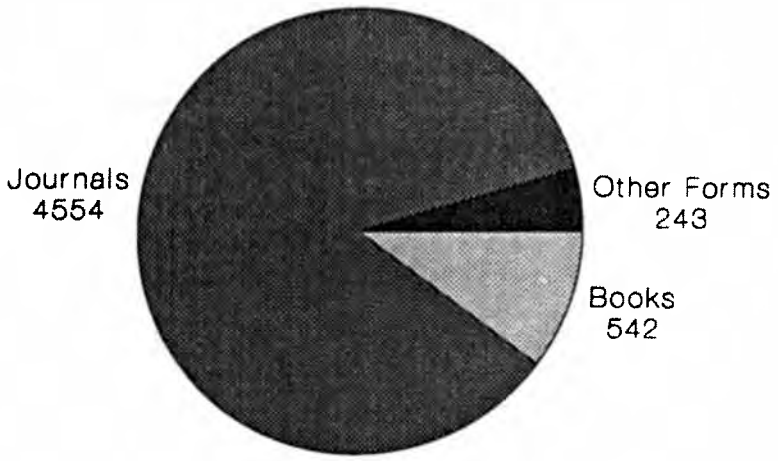


Figure 4-3

Citation Retrieved From UMB Environmental Scientists and Biologists by Publication Form: Other Publication Forms

1988 to 1993

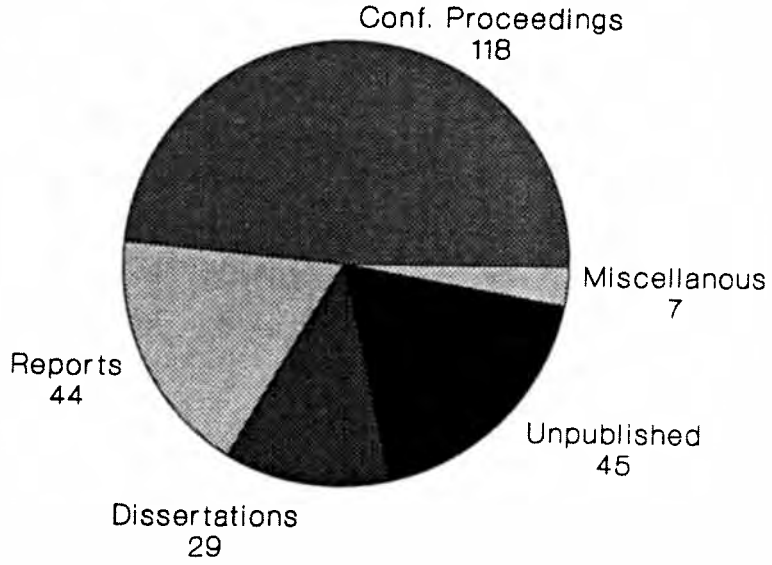


Table 4-1

Citation Patterns of UMB Environmental Scientist and Biologists by Publication Form

1988 to 1993

	Environmental Scientists		Biologists		Total	
Publication Forms	Citation Frequency	Percentage	Citation Frequency	Percentage	Citation Frequency	Percentage
Journals	1424	80.90%	3130	87.45%	4554	85.29%
Books	190	10.79%	352	9.83%	542	10.15%
Conference Proceedings	84	4.72%	34	.94%	118	2.2%
Reports	31	1.76%	13	.36%	44	.82%
Dissertations	12	.68%	17	.47%	29	.52%
Unpublished	14	.79%	31	.86%	45	.82%
Other	5	.28%	2	.05%	7	.10%
TOTAL	1760	100.0%	3579	100.0%	5339	100.00%

Research Question **What similarities and differences exist between the citation patterns of environmental scientists and biologists at UMB?**

As shown in Table 4-1, there were very small differences in the citation patterns of the UMB environmental scientists and biologists. We see rather similar statistical percentages. Both cited journals more than any other publication form combined -- 80.90% for the environmental scientists and 87.45% for the biologists. Book citing patterns are similar. There were differences in the citation patterns of proceedings and reports, as the UMB environmental scientist cited these more frequently than the biologists (4.72% vs. 0.94%). However, the citation frequency of remaining publication forms were similar for both groups.

biologists (4.72% vs. 0.94%). However, the citation frequency of remaining publication forms were similar for both groups.

Hypothesis **There is an isomorphic relationship between the citation patterns of environmental scientists and biologists at UMB.**

As shown in Table 4-1, the citation patterns of these scientists are quite similar. Therefore, it can be concluded that there is a resemblance in the citation patterns of both. Thus, the hypothesis is supported for journal, books, dissertations, and other types of publication forms. On the other hand, citations to proceedings and reports expose a difference in the citation patterns, however, the differences are minimal giving overall support to the isomorphic hypothesis.

Research Question **What journals and subjects do environmental scientists and biologists cite more frequently?**

One-hundred-three journals were cited by both environmental scientists and biologists. Nevertheless, each group had different citation frequencies for those titles. A list of core journals that included these and other journals cited by the UMB environmental scientists and biologists, respectively, is presented in Table 4-2, which excludes journals cited less than 5 times (see Appendix C for an alphabetical list of all journals cited).

Table 4-2

List of Journals Cited by UMB Environmental Scientists and Biologists by Citation Frequency

1988 to 1993

Environmental Scientists		Biologists	
Citation Frequency	Journal Cited	Citation Frequency	Journal Cited
60	*Environmental Science and Technology*	151	*Journal of Biological Chemistry*
49	*Applied and Environmental Microbiology*	131	*Archives of Insect Biochemistry and Physiology*
29	*Marine Pollution bulletin*	112	*FEBS Letters*
29	*Marine Biology*	98	*Insect Biochemistry*
29	*Archives of Microbiology*	93	*Science*
25	*Journal of Industrial Microbiology*	86	*Nature*
25	*Chemosphere*	57	*Bioorganic Chemistry*
24	*Limnology and Oceanography*	56	*Applied and Environmental Microbiology*
24	*Biochemical Journal*	56	*Advances in Insect Physiology*
22	*Nature*	48	*Biochemistry US*
22	*Marine Ecology Progress Series*	47	*Deep Sea Research*
21	*Organic Geochemistry*	45	*Evolution*
21	*Journal of General Microbiology*	41	*Cell*
21	*Geochimica et Cosmochimica Acta*	40	*American Naturalist*
20	*Microbial Ecology*	40	*Marine Ecology Progress Series*
20	*Agricultural and Biological Chemistry*	38	*American Journal of Botany*
20	*Marine Environmental Research*	37	*Proceedings of the National Academy of Sciences US*
20	*Applied Organometallic Chemistry*	33	*Biochimica et Biophysica Acta*
17	*Journal of Bacteriology*	33	*Journal of Cell Biology*
16	*Journal of Biological Chemistry*	31	*Nucleic Acid Research*
15	*Ecology*	30	*Ecology*
14	*Advances in Organic Geochemistry*	29	*Annual Review of Ecology and Systematics*
13	*Applied Microbiology*	27	*Biotropica*
13	*Journal of Agricultural and Food Chemistry*	26	*Journal of Insect Physiology*

12	*Biochimica et Biophysica Acta*
12	*European Journal of Biochemistry*
11	*Oecologia*
11	*Journal of Marine Research*
11	*FEMS Microbiology Ecology*
11	*Canadian Journal of Fisheries and Aquatic Sciences*
11	*Deep Sea Research*
10	*FEBS Letters*
10	*Canadian Journal of Microbiology*
10	*Chemico-Biological Interactions*
9	*Antonie Van Leeuwenhock Journal of Microbiology*
9	*Archives of Biochemistry and Biophysics*
9	*Analyst*
9	*Aquatic Toxicology*
8	*Analytical Chemistry*
8	*Developmental and Industrial Microbiology*
8	*Science of the Total Environment*
8	*Journal of Experimental Marine Biology and Ecology*
7	*Oceanologica Acta*
7	*Mutation Research*
7	*Archives of Environmental Contamination and Toxicology*
7	*American Naturalist*
7	*Environmental Technology Letters*
6	*Mycologia*
6	*Biochemical and Biophysical Research Communications*
6	*Journal of the Fisheries Research Board of Canada*
6	*Journal of the Marine Biological Association of the United Kingdom*
6	*Canadian Journal of Biochemistry*
6	*Annals of the New York Academy of Science*
25	*Investigative Ophthalmology and Visual Science*
25	*Proceedings of the Royal Society of London Series B*
23	*Oecologia*
23	*Journal of the American Chemical Society*
22	*Marine Biology*
22	*Developmental Biology*
22	*Cell and Tissue Research*
21	*Journal of Comparative Physiology*
21	*EMBO Journal*
21	*Limnology and Oceanography*
19	*Comprehensive Insect Physiology*
18	*Economic Botany*
18	*UCLA Symposia in Molecular and Cellular Biology*
18	*American Antiquity*
16	*Experimental Cell Research*
16	*Journal of Ultrastructure and Research*
15	*Journal of Experimental Biology*
15	*Malacologia*
15	*Vision Research*
14	*Tetrahedron*
13	*Biological Oxidation systems*
13	*Analytical Biochemistry*
13	*Methods in Enzymology*
13	*Molecular and Cellular Biochemistry*
12	*Biochemical Journal*
12	*Journal of Comparative Physiology A*
12	*Annals of the Missouri Botanical Garden*
12	*Experientia*
12	*Biological Journal of the Linnean Society*

5	*Environmental Toxicology and Chemistry*
5	*Planta*
5	*Estuarine, Coastal and Shelf Science*
5	*Botanica Marina*
5	*Experientia*
5	*Oceanus*
5	*Oceans*
5	*Bulletin of Environmental Contamination and Toxicology*
5	*Proceedings of the National Academy of Science*
5	*International Biodeterioration Bulletin*
5	*Toxicology and Applied Pharmacology*
5	*Toxicological Assessment and International Quarterly*
12	*European Journal of Biochemistry*
11	*Biochemical and Biophysical Research*
11	*Journal of Ecology*
11	*Zeitschrift fur Naturforschung C*
11	*Journal of the Marine Biological Association*
11	*Plant Molecular Biology*
11	*Theoretical and Applied Genetics*
10	*Revista del Museo Nacional del Peru*
10	*Journal of Molluscan Studies*
10	*Journal of General Physiology*
9	*Biology of Reproduction*
9	*Endeavour*
9	*Molecular and Cellular Biology*
9	*Kulturfplanze*
9	*Journal of Molecular Biology*
9	*Organic Preparations and Procedures International*
9	*Journal of Neurocytology*
8	*Journal of Investigative Dermatology*
8	*Experimental Eye Research*
8	*Journal of Experimental Marine and Biology and Ecology*
8	*Sea*
7	*Gamete Research*
7	*Microbial Ecology*
7	*Journal of the Chemical Society Chemical Communications*
7	*Annual Review of Entomology*
7	*Annual Review of Biochemistry*
7	*Oceanologica Acta*
7	*Annals of the Entomological Society of America*
7	*Quarterly Review of Biology*
6	*Heredity*
6	*Systematic Zoology*

6	*Maize Genetics Cooperation Newsletter*
6	*Oikos*
6	*Marine Environmental Research*
6	*Federation Proceedings*
6	*European Journal of Cell Biology*
6	*Geochimica et Cosmochimica Acta*
6	*Synthesis Stuttgart*
6	*Zoologica Scripta*
6	*Crop Science*
6	*Bioscience*
5	*Vision Research*
5	*Quaternary Research*
5	*Journal of General Microbiology*
5	*Journal of Heredity*
5	*Journal of Paleontology*
5	*Hydrobiologia*
5	*Annals of Botany*
5	*Journal of Research*
5	*Boletin del Seminario Arqueologico*
5	*Archives of Biochemistry and Biophysics*
5	*Botanical Museum Leaflets Harvard University*
5	*Advances in Microbial Ecology*
5	*American Anthropologist*

These core journals have different subjects emphases. Tables 4-3 is an alphabetical list of the core subjects of the journals cited by these academic scientists, while Table 4-4 is a ranked list by cited subject categories. As shown, the study population cited a wide range of journals from different subjects. All subjects are defined and assigned to the journals by ISI.

Table 4-3

Alphabetical List of *JCR* Journal Subject Categories Cited by UMB Environmental Scientists and Biologists

Environmental Scientists			Biologists		
Citation Frequency	Subject Category	Number of Journals Cited	Citation Frequency	Subject Category	Number of Journals Cited
13	Agriculture	1	6	Agriculture	1
125	Biochemistry and Molecular Biology	10	569	Biochemistry and Molecular Biology	20
5	Botany	1	81	Biology	5
20	Chemistry	1	100	Botany	5
17	Chemistry, Analytical	2	30	Chemistry	2
53	Ecology	4	86	Chemistry, Organic	4
198	Environmental Sciences	11	103	Cytology and Histology	6
7	Genetics and Heredity	8	8	Developmental Biology	1
21	Geosciences	1	185	Ecology	7
107	Marine and Freshwater Biology	9	344	Entomology	7
168	Microbiology	9	59	Environmental Sciences	3
38	Multidisciplinary Sciences	3	22	Genetics and Heredity	22
6	Mycology	1	5	Geology	1
38	Oceanography	4	6	Geosciences	1
5	Pharmacology	1	93	Marine and Freshwater Biology	6
5	Toxicology	1	66	Microbiology	3
			243	Multidisciplinary Sciences	6
			9	Obstetrics and Gynecology	1
			32	Oceanography	3
			56	Ophthalmology	4
			5	Paleontology	1
			43	Physiology	3
			31	Zoology	3

Many other subjects were cited, however, it was impossible to list all categories due to the few citations received. Table 4-3 includes only those with 5 or more citations.

Table 4-4

Ranked List of *JCR* Journal Subject Categories Cited by UMB Environmental Scientists and Biologists

Environmental Scientists			Biologists		
Citation Frequency	Subject Category	Number of Journals Cited	Citation Frequency	Subject Category	Number of Journals Cited
198	Environmental Sciences	11	569	Biochemistry and Molecular Biology	20
168	Microbiology	9	344	Entomology	7
125	Biochemistry and Molecular Biology	10	243	Multidisciplinary Sciences	6
107	Marine and Freshwater Biology	9	185	Ecology	7
53	Ecology	4	103	Cytology and Histology	6
38	Multidisciplinary Sciences	4	100	Botany	5
38	Oceanography	4	93	Marine and Freshwater Biology	6
21	Geosciences	1	86	Chemistry, Organic	4
20	Chemistry	1	81	Biology	5
17	Chemistry, Analytical	2	66	Microbiology	3
13	Agriculture	1	59	Environmental Sciences	3
7	Genetics and Heredity	1	56	Ophthalmology	4
6	Mycology	1	43	Physiology	3
5	Botany	1	32	Oceanography	3
5	Pharmacology	1	31	Zoology	3
5	Toxicology	1	30	Chemistry	2
			22	Genetics and Heredity	3
			9	Obstetrics and Gynecology	1
			8	Developmental Biology	1
			6	Agriculture	1
			6	Geosciences	1
			5	Geology	1
			5	Paleontology	1

Table 4-5 includes the core journals cited grouped by subject category listed in the table above. As shown in this and the preceding tables, environmental scientists cite core

journals from 16 subject categories. Biologists cited core journals from 23 subject categories.

The twelve subject categories common to both groups, as shown on Table 4-4 are:

- Agriculture;
- Biochemistry and Molecular Biology;
- Botany;
- Chemistry;
- Ecology;
- Environmental Sciences;
- Genetics and Heredity;
- Geosciences;
- Marine and Freshwater Biology;
- Microbiology;
- Multidisciplinary Sciences; and
- Oceanography.

Although the top subject categories cited differ from the group of environmental scientists to that of the biologists, the commonly highly cited subjects can be identified as:

- Environmental Sciences;
- Ecology;
- Biochemistry and Molecular Biology;
- Microbiology;
- Multidisciplinary Sciences; and
- Oceanography.

Clearly, from this discussions, it is evident that Table 4-5, a subject category list for all core journals for the UMB environmental scientists and biologists, that can be used as a guide collection development at HL.

Table 4-5

Core List of Journals Cited by UMB Environmental Scientists and Biologists by *JCR* Subject Category by Citation Frequency 1988 to 1993

	Environmental Scientists		Biologists	
Subject Category	Citation Frequency	Cited Journal	Citation Frequency	Cited Journal
Agriculture	13	*Journal of Agriculture of Food Chemistry*	6	*Crop Science*
Biochemistry and Molecular Biology	24	*Biochemistry Journal*	151	*Journal of Biological Chemistry*
	20	*Agricultural and Biological Chemistry*	112	*FEBS Letters*
	16	*Journal of Biological Chemistry*	48	*Biochemistry US*
	12	*Biochimica et Biophysica Acta*	41	*Cell*
	12	*European Journal of Biochemistry*	33	*Biochimica et Biophysica Acta*
	10	*Chemico-Biological Interactions*	31	*Nucleic Acids Research*
	9	*Archives of Biochemistry and Biophysics*	21	*EMBO Journal*
	6	*Biochemical and Biophysical Research Communications*	13	*Analytical Biochemistry*
	6	*Canadian Journal of Biochemistry*	13	*Methods in Enzymology*
			13	*Molecular and Cellular Biochemistry*
			12	*Biochemical Journal*
			12	*European Journal of Biochemistry*
			11	*Biochemical and Biophysical Research Communications*
			11	*Zeiftschrift fur Naturoforshung C: a Journal of Bioscience*

			11	*Plant Molecular Biology*
			9	*Molecular and Cellular Biology*
			9	*Journal of Molecular Biology*
			7	*Annual Review of Biochemistry*
			6	*European Journal of Cell Biology*
			5	*Archives of Biochemistry and Biophysics*
Biology			25	*Proceedings of the Royal Society of London Series B*
			22	*Developmental Biology*
			15	*Journal of Experimental Biology*
			12	*Biological Journal of the Linnean Society*
			7	*Quarterly Review of Biology*
Botany	5	*Planta*	38	*American Journal of Botany*
			27	*Biotropica*
			18	*Economic Botany*
			12	*Annals of the Missouri Botanical Garden*
			5	*Annals of Botany*
Chemistry	20	*Applied Organometallic Chemistry*	23	*Journal of the American Chemical Society*
			7	*Journal of the Chemical Society: Chemical Communications*
Chemistry, Analytical	9	*Analyst*		
	8	*Analytical Chemistry*		

Chemistry, Organic				57	*Bioorganic Chemistry*
				14	*Tetrahedron*
				9	*Organic Preparations and Procedures International*
				6	*Synthesis Stuttgart*
Cytology and Histology				33	*Journal of Cell Biology*
				22	*Cell and Tissue Research*
				16	*Experimental Cell Research*
				9	*Journal of Ultrastructure Research*
				7	*Gamete Research*
Dermatology and Venereal Diseases				8	*Journal of Investigative Dermatology*
Ecology	10	*Microbial Ecology*		45	*Evolution*
	15	*Ecology*		40	*American Naturalist*
	11	*Oecologia*		30	*Ecology*
	7	*American Naturalist*		29	*Annual Review of Ecology*
				23	*Oecologia*
				11	*Journal of Ecology*
				7	*Oceanologica Acta*
Entomology				131	*Archives of Insect Biochemistry and Physiology*
				98	*Insect Biochemistry*
				56	*Journal of Insect Physiology and Biochemistry*
				26	*Journal of Insect Physiology*

			19	*Comprehensive Insect Physiology*
			7	*Annual Review of Entomology*
			7	*Annals of the Entomology Society of America*
Environmental Sciences	60	*Environmental Science and Technology*	47	*Deep Sea Research*
	29	*Marine Pollution Bulletin*	6	*Marine Environmental Research*
	25	*Chemosphere*	6	*Bioscience*
	21	*Organic Geochemistry*		
	20	*Marine Environmental Research*		
	11	*Deep Sea Research*		
	8	*Science of the Total Environment*		
	7	*Archives of Environmental Contamination and Toxicology*		
	5	*Environmental Toxicology and Chemistry*		
	5	*Bulletin of Environmental Contamination*		
Genetics and Heredity	7	*Mutation*	11	*Theoretical and Applied Genetics*
			6	*Heredity*
			5	*Journal of Heredity*
Geology			5	*Quaternary Research*
Geosciences	21	*Geochimica et Cosmochimica Acta*	6	*Geochimica et Cosmochimica Acta*

Marine and Freshwater Biology	29	*Marine Pollution Bulletin*	40	*Marine Ecology Progress Series*
	22	*Marine Ecology Progress Series*	21	*Marine Biology*
	11	*Journal of Marine Research*	11	*Journal of the Marine Biological Association*
	11	*Canadian Journal of Fisheries and Aquatic Sciences*	8	*Journal of Experimental Marine Biology and Ecology*
	9	*Aquatic Toxicology*	8	*Sea*
	8	*Journal of Experimental Marine Biology and Ecology*	5	*Hydrobiologia*
	6	*Journal of the Marine Biological Association*	5	*Journal of Marine Research*
	6	*Journal of the Fisheries Research Board of Canada*		
	5	*Botanica Marina*		
Microbiology	49	*Applied and Environmental Microbiology*	56	*Applied and Environmental Microbiology*
	29	*Archives of Microbiology*	5	*Advances in Microbial Ecology*
	21	*Journal of General Microbiology*	5	*Journal of General Microbiology*
	17	*Journal of Bacteriology*		
	13	*Applied Microbiology*		
	11	*FEMS Microbiology Letters*		
	10	*Canadian Journal of Microbiology*		
	9	*Antonie Van Leeuwenhock Journal of Microbiology*		
	8	*Developmental and Industrial Microbiology*		

Multidisciplinary Sciences	22	*Nature*	93	*Science*
	5	*Experientia*	86	*Nature*
	5	*Proceedings of the National Academy of Science US*	37	*Proceedings of the National Academy of Science US*
			12	*Experientia*
			9	*Endeavour*
			6	*Federation Proceedings*
Mycology	6	*Mycologia*		
Obstetrics and Gynecology			9	*Biology of Reproduction*
Oceanography	24	*Limnology and Oceanography*	27	*Limnology and Oceanography*
	7	*Oceanologica Acta*	7	*Oceanologica Acta*
	5	*Estuarine, Coastal and Shelf Science*		
	5	*Oceanus*		
Ophthalmology			25	*Investigative Ophthalmology and Visual Science*
			15	*Vision Research*
			8	*Eye Experimental Research*
Ornithology			1	*Audubon*
			1	*Bird Banding*
			1	*Ibis*
			1	*Journal of Field Ornithology*
			1	*Ostrich*
Paleontology			5	*Journal of Paleontology*

Pharmacology and Pharmacy	5	*Toxicology and Applied Pharmacology*		
Physiology			21	*Journal of Comparative Physiology*
			12	*Journal of Comparative Physiology A*
			10	*Journal of General Physiology*
Toxicology	5	*Toxicological Assessment*		
Zoology			15	*Malacologia*
			10	*Journal of Molluscan Studies*
			6	*Systematic Zoology*

Objective 2 ***To compare the rankings of the journals cited by the UMB environmental scientist and biologists with those of JCR.***

From 1988 to 1992 the UMB environmental scientists made 1,316 citations to journal articles, on the other hand, the UMB biologists cited 2,875 journal articles. As the 1993 *JCR* was not available at the time of this study, the 1993 citations to journal articles made by these academic scientists had to be excluded from the isomorphic analysis procedure and the "journal rankings" correlation test.

Table 4-6 provides year to year detailed statistics on the resemblance of the ranking order of the journals cited by the two study groups with that of *JCR*. This journal ranking data are tabulated by isomorphic, non-isomorphic, as well as "missing

data" for "No *JCR* Ranking Data". This table was generated with the procedures described on Chapter 3 under "Isomorphism". Table 4-6 results are further presented in Figures 4-4 and 4-5.

Table 4-6

Isomorphic Comparison of the Rankings of the Journals Cited by the UMB Environmental Scientists and Biologists with *JCR* Rankings 1988 to 1992

Year	Environmental Scientists						Biologists					
	Isomorphic Rankings		Non-isomorphic Rankings		No JCR Ranking Data		Isomorphic Rankings		Non-isomorphic Rankings		No JCR Ranking Data	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1988	7	8	63	76	13	16	13	9	112	73	27	18
1989	10	8	102	79	17	13	14	11	100	76	17	13
1990	10	6	117	76	27	18	16	5	130	48	127	47
1991	3	3	79	78	19	19	10	16	45	73	7	11
1992	4	5	67	80	13	15	16	11	108	72	27	17

Table 4-6 and Figures 4-4 and 4-5, show that the ranking order of the journals cited by the UMB environmental scientists and biologists generally did not resemble that of *JCR*. For example, in 1988, environmental scientists cited a total of 83 journals. Of these, the descending citation frequency ranking order resembled that of *JCR* in only seven cases (8%). The ranking order of 63 (76%) of the journals cited by the UMB environmental scientists did not resemble that of *JCR*. Thirteen (16%) of journals cited by the UMB environmental scientists were not included in *JCR*, thus they could not be compared with *JCR* journal ranking order.

Figure 4-4

Isomorphic Comparison of the Rankings of the Journals Cited by the UMB Environmental Scientists with *JCR*

1988 to 1992

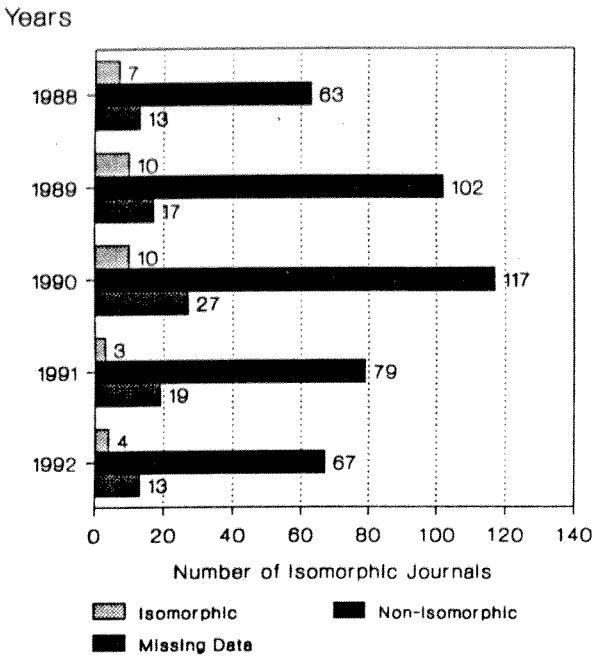
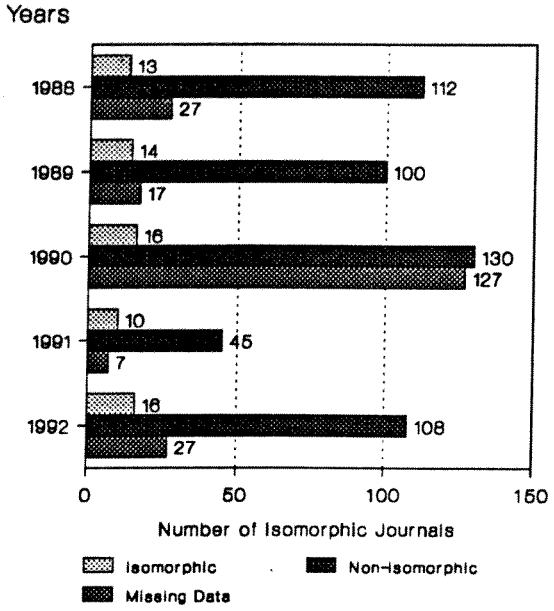


Figure 4-5

Isomorphic Comparison of the Rankings of the Journals Cited by the UMB Biologists with *JCR*

1988 to 1992



Hypothesis **There is an isomorphic relationship between the rankings of the journals cited by the UMB environmental scientists and biologists and that of *JCR*.**

As shown on Table 4-6, the rankings of the journals cited by the UMB environmental scientists and biologists when compared to those of *JCR* generally do not resemble the ranking order of journals in *JCR*. Thus, the hypothesis is not supported. However, it is clear that UMB environmental scientists and biologists cite *JCR* journals more that any other journal as shown by the small statistical percentages of "No *JCR* Ranking Data" on the table.

Hypothesis **In comparing the ranking order there is no statistically significant difference (at the 0.05 level) between the ranking order of the journals cited by the UMB environmental scientists and biologists and the ranking order of *JCR* journals.**

In contrast with the differences found between the ranking order of journals cited by the study population and that of *JCR*, the rank correlation coefficient test showed that these rankings are statistically similar. Table 4-7, Figures 4-6 and 4-7 clearly show that the rankings of the journals cited by these academic scientists had high statistical correlations with that of *JCR*.

As shown in Table 4-7, Spearman's Rank Correlation Coefficient (Spearman's rho) revealed high correlations between the rankings of the journals for all years, except in 1992 when the statistical correlation was moderate. For example, in 1988, the correlation value found for the rankings of the journals cited by the UMB environmental scientists and that of *JCR* was 0.297. Since the critical value prescribed by Zar (1972) for the number of rankings tested at the 0.05 level of confidence is 0.198, which is much lower that 0.297, there is a high correlation between the rankings of the journals cited by these

academic scientists and that of *JCR*. Thus, the hypothesis was supported.

Table 4-7

Statistical Correlation of the Rankings of the Journals Cited by the UMB Environmental Scientists and Biologists with *JCR* Journal Rankings with Spearman's Rank Correlation Coefficient (rho)

1988 to 1992

Year	Environmental Scientists				Biologists			
	Number of Journals Cited	Spearman's rho Value Found	Statistically Significant Correlation Value at 0.05 level	Statistical Correlation Found	Number of Journals Cited	Spearman's rho Value Found	Statistically Significant Correlation Value at 0.05 level	Statistical Correlation Found
1988	83	0.297	0.198	High	152	0.309	<0.165	High
1989	129	0.172	<0.165	High	131	0.281	<0.165	High
1990	154	0.344	<0.165	High	273	0.196	<0.165	High
1991	101	0.193	>0.183	High	62	0.348	<0.226	High
1992	84	0.186	0.198	Moderate	151	0.063	<0.165	Moderate

Objective 3 ***To identify the half-life of the journals cited by the UMB environmental scientists and biologists and compare it with that of JCR.***

Hypothesis **There is an isomorphic relationship between the half-life data of the journals cited by the UMB environmental scientists and biologists and that of *JCR*.**

The half-life of all journals cited by the study population was calculated using the *JCR* "half-life" formula described on Chapter 3 under "Half-Life". Half-life isomorphism was defined for this study on that same chapter under "Isomorphism".

Figure 4-6

Statistical Correlation of the Rankings of the Journals Cited by the UMB Environmental Scientists with *JCR* Journal Rankings with Spearman's Rank Correlation Coefficient (rho)

1988 to 1992

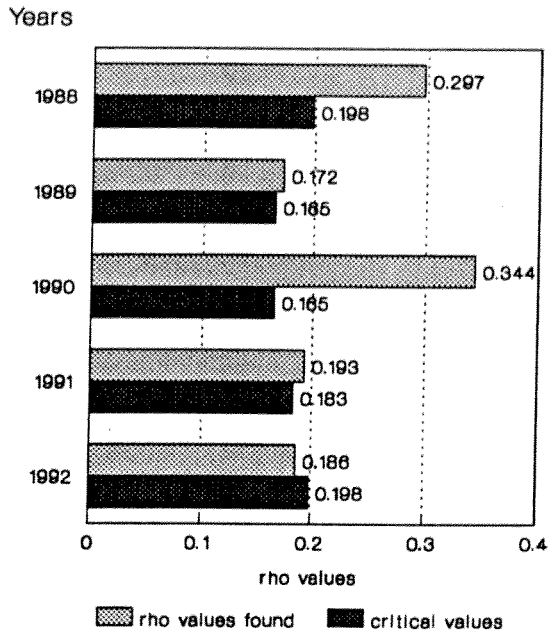
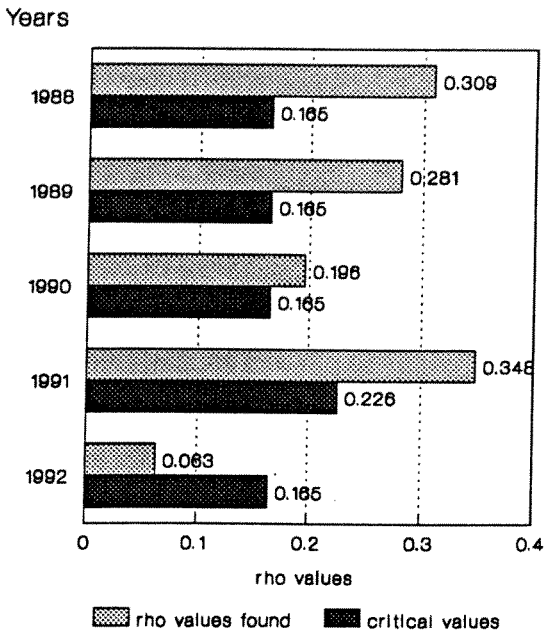


Figure 4-7

Statistical Correlation of the Rankings of the Journals Cited by the UMB Biologists with *JCR* Journal Rankings with Spearman's Rank Correlation Coefficient (rho)

1988 to 1992



As shown below in Table 4-8 and Figures 4-8 (a & b) and 4-9 (a & b), the half-life of the journals cited by the UMB environmental scientists and biologists respectively did not resemble that of *JCR*. For example, in 1988 the half-life of 42 (28%) of the journals cited by the UMB biologists was isomorphic with those of *JCR* while the half-life of 82 (54%) of the cited journals did not resemble that of *JCR*. The remaining twenty-eight (20%) journals cited by this group had no half-life data in JCR.

Thus the findings did not support the hypothesis. The half-life of the journals cited by the study population generally are not isomorphic with that of *JCR*.

Table 4-8

Isomorphism of Half-Life Data of Journals Cited by the UMB Environmental Scientists and Biologists and in *JCR*

1988 to 1992

Year	Environmental Scientists						Biologists					
	Isomorphic Half-life		Non-isomorphic Half-life		No JCR Half-life Data		Isomorphic Half-life		Non-isomorphic Half-life		No JCR Half-life Data	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
1988	19	23	48	58	16	19	42	28	82	54	28	18
1989	22	17	86	67	21	13	37	28	75	57	19	15
1990	47	31	78	51	29	18	57	21	91	33	121	46
1991	29	29	51	50	21	21	15	24	40	64	7	12
1992	24	29	45	53	15	18	51	34	73	48	27	18

Figure 4-8

Isomorphism of Half-Life Data of the Journals Cited by the UMB Environmental Scientists with *JCR* Half-Life Data

1988 to 1992

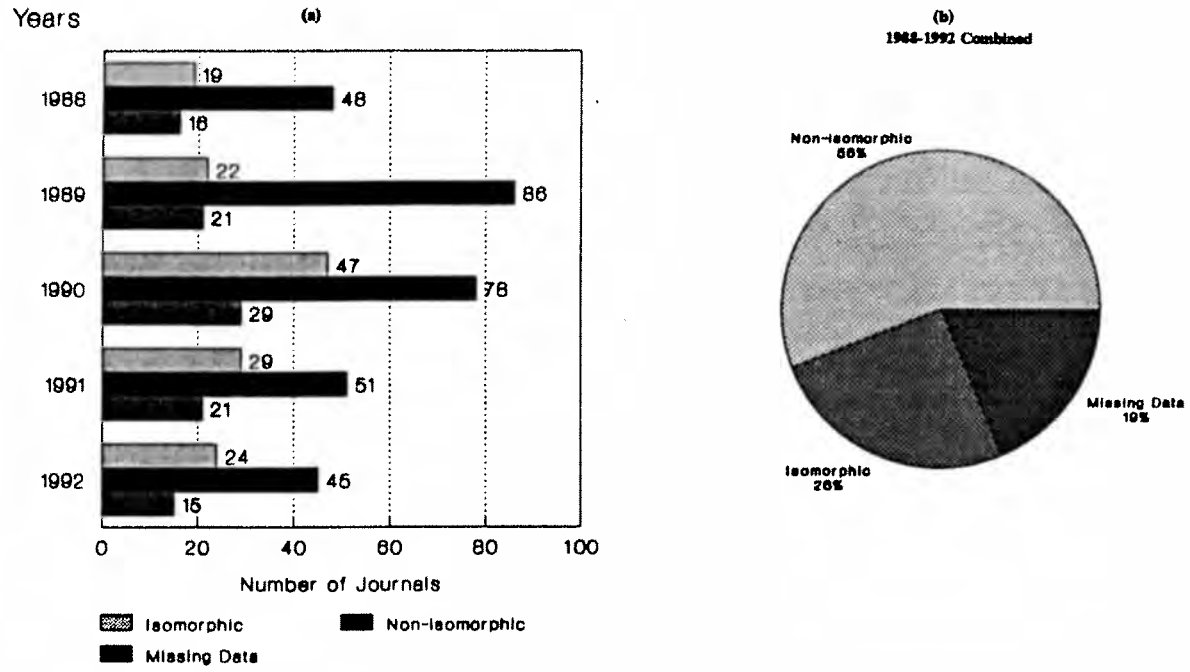
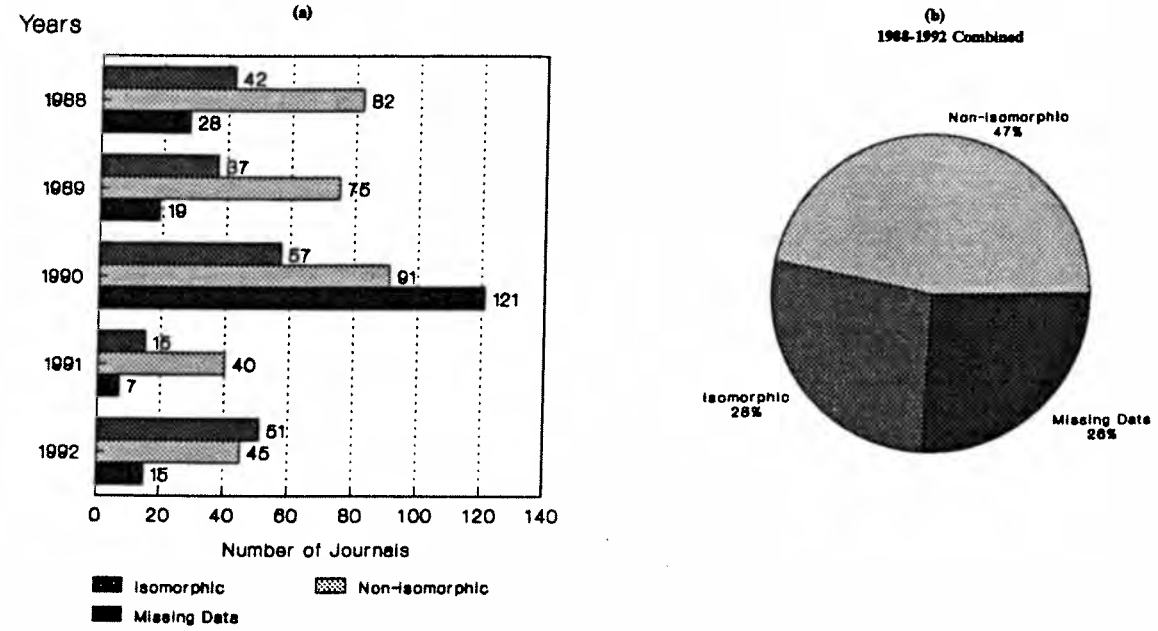


Figure 4-9

Isomorphism of Half-Life Data of the Journals Cited by the UMB Biologists with *JCR* Half-Life Data

1988 to 1992



Objective 4 ***To compare the half-life data of the journals cited by the UMB environmental scientists and biologists with that of JCR (by subject category).***

All journals cited by the UMB environmental scientists and biologists were grouped by their *JCR* subject category. Then, the half-life data of these journals was compared with those of *JCR* in that subject category. Although these scientists cited many more subject categories than those included in the table included in this chapter, logistically, it was impossible to make comparison of the half-life data of one single journal. For this reason, this investigator decided to exclude from the test subject categories that had half-life data for less than five journals in the category.

The results indicate that the half-life of the journals cited by these scientists generally are not similar to that of *JCR*, either by an across-the-board comparison or by grouping journals by their subject category.

Hypothesis **There is an isomorphic relationship between the half-life data of the journals cited by the UMB environmental scientists and biologists and that of *JCR* (by subject category).**

Figures 4-10 and 4-11 show that the half-life of the journals cited by the UMB environmental scientists and biologists does have a slight resemblance with that of *JCR* when grouped by subject category. However, the resemblance was far less obvious than expected, thus the hypothesis was not supported.

Appendix D offers detailed statistical data on the results of this test. This table clearly shows the findings by subject category year to year. For example, in 1988, the half-life of two journals (25%) cited by the UMB environmental scientists from the

Biochemistry and Molecular Biology subject category were isomorphic with those of *JCR*, while six others (75%) were not. On the other hand, the half-life data of the journals in the *Oceanography* subject category resembled that of *JCR* in all five years included in the study.

Appendix D also shows that between 1988 and 1992, the half-life of the journals cited by these academic scientists were isomorphic with those of *JCR* in 46 (51.1%) of the 90 subject categories year to year -- 23% for environmental scientists and 27% for biologists. For the UMB environmental scientists these subject categories were: *Botany; Chemistry; Chemistry, Inorganic and Nuclear; Ecology; Environmental Sciences; Marine and Freshwater Biology; Microbiology; Oceanography*; and *Toxicology*; and for the UMB biologists these subject categories were: *Biology; Chemistry, Organic; Cytology and Histology; Ecology; Entomology; Environmental Sciences; Genetics and Heredity; Marine and Freshwater Biology; Microbiology; Oceanography; Ornithology*; and *Zoology*.

Appendix D further shows that despite the small resemblance found, some patterns did emerge. For example, the half-life of the journals cited in the *Biology* subject category by the UMB biologists were isomorphic with those of *JCR* in every year examined in this study. Less agreement was found with the half-life of journals in other subject categories, however, generally the half-life of journals in core subject categories listed on this chapter under "Objective 1" did much better that those in other subject categories -- the half-life of the journals cited by the study population were isomorphic with those of *JCR* more times year to year than with any other subject category.

Figure 4-10

Isomorphism of Half-Life Data of the Journals Cited by the UMB Environmental Scientists with *JCR* Half-Life Data by Subject Category

1988 to 1992

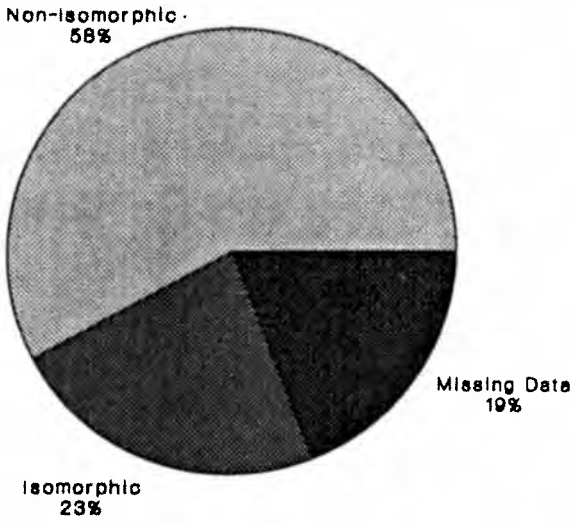
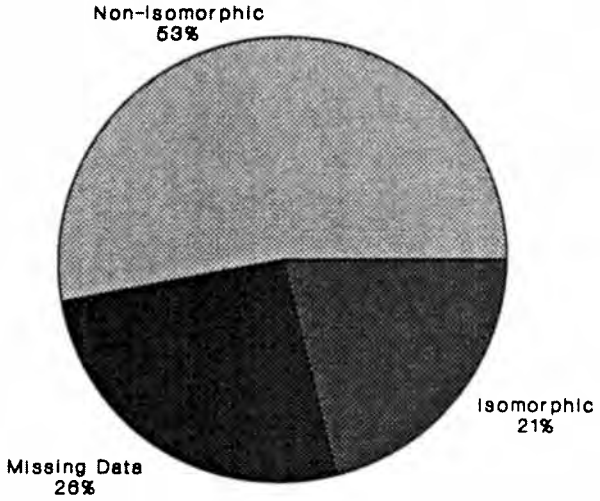


Figure 4-11

Isomorphism of Half-Life Data of the Journals Cited by the UMB Biologists with *JCR* Half-Life Data by Subject Category

1988 to 1992



Objective 5 ***To compare the ranking order of journals cited by the UMB environmental scientists and biologists with that of JCR (by subject category).***

The ranking order of the journals cited by the UMB environmental scientists and biologists was compared to that of *JCR* by subject category. As stated earlier, subject categories with less than five cited journals were excluded from the test.

Figures 4-12 and 4-13 show that there was a resemblance in the ranking order of the journals cited by these scientists and that of JCR when grouped by subject category[17].

Appendix E is a detailed table with statistical data on the results of the comparison of the ranking order by subject category of the journals cited by the study population with those of *JCR*. This table clearly shows, with statistical percentages, the similarities and differences found in the test. For example, in 1988, the ranking order of six (60%) journals from the *Environmental Sciences* subject category cited by the UMB environmental scientists was isomorphic with those of JCR, while only four (40%) were not. Thus, the hypothesis was supported.

Further examination of Appendix D and Appendix E reveals interesting similarities between the findings in both tests. For example, the core subjects common to both study groups listed under "Objective 1" of this chapter have the largest number of isomorphic "half-life" with those of *JCR*. These same subject categories also have the highest number of "journal rankings" isomorphic with the ranking order of journals by impact factor in *JCR*. This suggests that journals cited in the core subject categories identified through this study deserve more special attention from HL librarians for collection development purposes.

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[17]*JCR* subject categories rank journals by impact factors. According to *JCR*, the impact factor is "a measure of the frequency with which the average article in a journal has been cited in a particular year. The *JCR* impact factor is basically a ratio between citations and citable items published. Thus, the 1988 impact factor of a journal X would be calculated by dividing the number of all the *SSCI/SCI/A&HCI* source journals' 1988 citations of journal X published in 1986 and 1987 by the total number of source items published in 1986 and 1987."

Figure 4-12

Isomorphic Comparison of the Rankings of the Journals Cited by the UMB Environmental Scientists with *JCR* Rankings by Subject Category

1988 to 1992

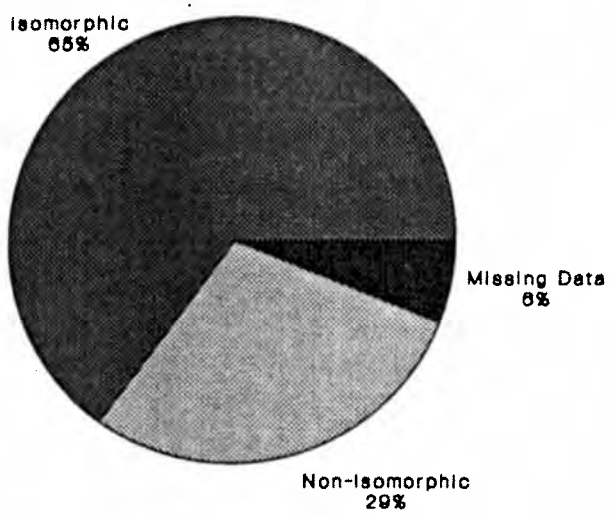
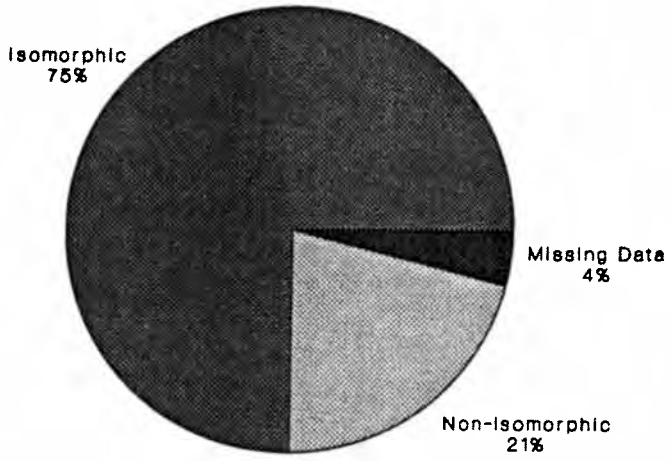


Figure 4-13

Isomorphic Comparison of the Rankings of the Journals Cited by the UMB Biologists with *JCR* Rankings by Subject Category

1988 to 1992



Hypothesis **There is an isomorphic relationship between the ranking order of journals cited by the UMB environmental scientists and biologists and that of *JCR* (by subject category).**

Generally, the ranking order of the journals cited by the study population resembled that of *JCR*. For example, from 1988 to 1992, environmental scientists cited journals from twenty-seven categories, and twenty-one (78%) of these had journals with a similar ranking order to those in *JCR* . On the other hand, the rankings of the journals cited by the UMB biologists were similar in twenty-five subject categories (68%) with those of *JCR* in those subjects. Adding these up, both study groups had forty-six subject categories (72%) in total that were isomorphic to those of *JCR*. Thus the hypothesis was supported.

Hypothesis **In comparing ranking order of journals there is no statistically significant difference (at the 0.05 level) between the ranking order of journals cited by the UMB environmental scientists and biologists and the ranking order of *JCR* journals by impact factor.**

Appendix F shows that the correlation of the rankings of the journals cited by the study population with those of *JCR* varied significantly. For example, in 1992, the correlation found for the ranking of the journals cited by the environmental scientists from the *Biochemistry and Molecular Biology* subject category and that of *JCR* was 0.577. Since the critical value is 0.643, which is higher than 0.577, there is a moderate correlation between the two sets of "journal rankings". On the other hand, the rankings of the journals cited by the biologists that same year and from that same subject category had a correlation value of 0.080 with those of *JCR*, far distant from the required critical value of 0.377. Thus there is no correlation between the two rankings.

Although there is a wide-range of statistical differences in the Spearman's rho test results, some patterns emerged. For instance, the core subjects common to both study groups listed under

"Objective 1", generally did better than other subjects. In other words, the rankings of journals cited from the *Environmental Sciences*, *Marine and Freshwater Biology*, *Microbiology*, and *Oceanography* subject categories generally correlated more frequently and higher with those of *JCR* more than any other subject category in the test.

Discussion of the Findings

The discussions in this chapter thus far finds that the study population cited different publication forms, but they cited journals more frequently than any other publication forms combined. The cited journals were further analyzed by citation frequency and by subject categories. The ranking order of these cited journals was then compared to the scientific community in general as represented by *JCR*. The following section compares the findings of the study to that of other studies providing additional framework for the discussion to come in Chapter 5.

Journal Citation Patterns

Over 80% of the citations of the study population were to journals. These findings are similar to that of other studies. For example, Hurd (1992) found that 87% of the citations in her study of the chemists at the University of Illinois-Chicago (UIC) were to journals, a similar percentage to the one found in this study. On the other hand, Kelland (1990) found that the ecologists and biochemists in his study had a similar reliance on journals, 83% of their citations were to this publication form, a very similar percentage to that of this study. Another similar finding was produced by Brown (1956) who found that zoologists citations to journals were

80.08% of the total items cited. On the other hand, other studies have found that scientists cited journals more frequently than the findings of this study. For example, Fussler (1949) found that the chemists and physicists cited journals 94% and 93% of the times, respectively, a larger but not so distant percentage to the one found in this study.

It is clear that the UMB environmental scientists and biologists rely on journals more than on any other publication form for formal communication. Other studies, besides the ones discussed above, have found that scientists do use journals more frequently than any other publication form. For instance, Voigt (1959) found that scientists resort to journals to satisfy information needs, and that in their search for information journals are a relevant and frequently used source. The first section of Chapter 2 discussed these studies. As for many other scientists, journals are the most important formal information exchange medium for the UMB environmental scientists and biologists. This reliance on journals might be the first indicator that the study population scientific paradigm is similar to that of other scientists.

In addition to the analysis conducted, the citations of the study population were studied to determine journal scattering patterns. It was found that the journal citation patterns of these academic scientists conformed to Bradford's Law of Scattering.[18] For example, environmental scientists cited 1,424 journal articles, of these nineteen journals yielded 33.50% of the cited items. The second scattering zone included fifty journals that yielded 33.42% of the citations. In the third zone 33.08% of the citations came from 239 journals. On the other hand, biologists cited 3,130

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[18]Bradford (1950) discovered that a small number of journals yield a high portion of relevant items. Bradford identified three areas or scatter zones. Each of these areas of scattering yield one third of the relevant cited sources. In the first citation to many items come from a few journals, in the second area more sources yield on third of the cited items, the last third of cited items comes from a very large number of sources.

journal articles, sixteen journals yielded 33.16% of the citations. The second scattering zone, 32.71% of the cited items, included seventy journals, while the remaining 376 journals yielded 34.13% of the cited items. Similar scattering patterns has been found in many studies on scientists' citations, therefore, this is a second indicator that the study population conforms to citation patterns of other scientists and that they might as well conform to the existing scientific paradigm.

After these discussions it becomes more clear that Table 4-2 serves a list of core journals for these two groups of scientists. Of this list, fifty journals yield 66.92% of the citations of the environmental scientists, while eighty-seven journals yielded 65.87% of the biologists citations. These findings are different to those of Chen (1972). In her study she found that 90% of the physicists use of journals at MIT concentrated on 49 titles, a distant figure from the statistical percentages and number of journals in this study that fall short in reaching the 90% mark. On the other hand, Hurd (1992) found that the interdisciplinary research of chemists at UIC required more journals to reach that mark. In her study she found that chemists cited chemistry journals 51% of the times. while the other citation were scattered in biochemistry, biology, physics, and engineering journals. These patterns are closer to the ones found in this study, a close examination of Table 4-5 clearly reveals these patterns as it shows that these scientists, much more interdisciplinary in nature, draw citations from many journals from different disciplines besides their core journals/subjects.

Citation by Subject Category

The UMB environmental scientists cited journals from different subject categories, as shown the citations were scattered throughout the subjects in Table 4-4. Three subject categories

yielded 34.48% of the citations, these were: *Biochemistry and Molecular Biology*, *Environmental Sciences*, and *Microbiology*. Thirteen subjects yielded 25.52% of the citations, while the remaining 42% of the citations were scattered in the remaining subject categories.

On the other hand, UMB biologists also cited journals from different subject categories. The journals in three subject categories yielded 36.93% of the citations. These subject categories were: *Biochemistry and Molecular Biology*, *Entomology*, and *Multidisciplinary Sciences*. The journals in fourteen subject categories yielded 30.13% of the citations while the rest of their citations were scattered in remaining subject categories examined in this study.

Thus the scattering of the items cited by the study population when grouped by *JCR*'s subject categories also conforms to Bradford's Law of Scattering. The distribution of the citations suggests that the relevance of these subject categories is proportional to the number of citations made to the journals in these categories and that the research, publishing interests, and journal needs of the study population are reflected in this distribution.

Both groups of academic scientists cited a high number of journals from the following subject categories :

- Biochemistry and Molecular Biology;
- Chemistry;
- Environmental Sciences;
- Marine and Freshwater Biology;
- Microbiology; and
- Oceanography.

This list comprise the core subjects for the study population. Throughout the presentation of the findings these subjects have been constantly referred to as they deemed results that

supported the study hypotheses or showed clearly that the study population relies on journals in these subjects as core for their research.

Language of Cited Items

The language of the cited items was not a variable included in this investigation, but this researcher observed that the majority of the cited journals and items were in English. Examination of Table 4-2, and Appendix C shows that 92.2% of the cited journals are in English. References to journals that publish in other languages was only 7.80% of the total journals cited. These findings are similar to those of Chen (1972). She found that 95.3% of the physics journals used at MIT were in English. Far distant in time and location, Hwang (1991) found that electric and electronic engineers in Korea cited English language journals in over 80% of the cases. It is clear that English is the language of communication for the UMB environmental scientists and biologists. This should be included in the HL collection development policy.

Ranking Correlation and Isomorphic Tests

The "journal ranking" correlation test by subject category suggests that the frequency that these scientists cite *JCR* journals generally is not statistically similar to that of other scientists, as represented in *JCR*. Yet the isomorphic test suggested the opposite. These findings are similar to those of Pan (1978). She found no correlation between the in-house journal use frequency rankings and *JCR* impact factors. Pan suggested that impact factors are measures of potential use and not actual use. Other studies, such as Wiberly (1982) and Rice (1979) had similar findings. However, Stankus and Rice (1987) found a high correlation and good isomorphic resemblance between the ranking generated from in-house use of journal use at SUNY-Albany and *JCR* impact factors journal rankings by subject category.

On the other hand, the rankings of journals cited by the study population when correlated with those of *JCR* using Spearman's rho in an across-the-board comparison were found to be statistically similar. Yet, the isomorphic test suggested the opposite. The findings of other studies have provided conflicting data as the one found in this study. Discussions on Chapter 2 elaborated on the findings of those studies.

As the statistical correlation and the isomorphic findings presented conflicting evidence. It seems that the citation patterns of the study population and the scientific community in general are similar but that there are some differences. However, it is still unclear how the differences arise. Whether they came from the definition of impact factor, or from what citations are, from problems associated with the number of journals per subject category, or methodological issues related to the definitions of isomorphism as discussed on Chapters 2 and 3, the questions still exists.

Cited Half-Life Tests

The half-life of the journals cited by the study population was not isomorphic with that of *JCR*, either by an across-the-board comparison or divided by the journal's subject category. The differences found may be explained by problems related to *JCR*'s half-life formula. For example, *JCR* calculates the half-life of journals cited one-hundred times or more, a requirement not satisfied by any of the journals cited by the UMB environmental scientists and biologists year to year. The formula might skew the half-life calculation for journals cited less than a hundred times. ISI staff was unaware if this formula could generate such problems. Yet they consider the formula useless for less than the stipulated number of citations (Janet Robertson, Personal Communication, March 10, 1994).

On the other hand, the half-life concept has generated some controversy. For example, Broadus (1977) is opposed to the use of citations to determine the half-life of journals and other library materials. He noted that the half-life concept is misleading as it does not take into account the growth of the literature and it overestimates scientists' need for recent publications. Broadus explains that half-life is an attempt to express how any given use of materials will decrease exponentially over the years. He contends that this aging factor does not necessarily hold true. He feels that new and different ideas have a more difficult time breaking into the cited "corpus" and that long forgotten bodies of literature will be eventually used by scientists. Therefore, the decay patterns is far more irregular than supposed. These notions are also supported by Line (1970), Line and Carter (1974) and Line (1974). These researcher found that highly cited sources continued to be cited over time, independent from the expected recency of citations in the fields they studied. However, Price (1965) contends that citations to "classics" are responsible for most of the citations to older materials and that half-life is a good indicator of the usefulness of library materials.

Despite that controversy, the analysis performed pointed out some general trends and interesting findings. For example, the half-life of the journals cited by the UMB environmental scientists was of eight years for 1988 citations, seven for 1989, six for 1990, seven for 1991, and five for 1992. On the other hand, the half-life of the journals cited by the UMB biologists was of nine years for 1988, seven for 1989, six for 1990, and seven for 1991 and 1992. These findings conform to Price (1965) findings where the median half-life of the journals cited by scientists is less that ten years.

Furthermore, the age of the items cited by the study population were analyzed as whole

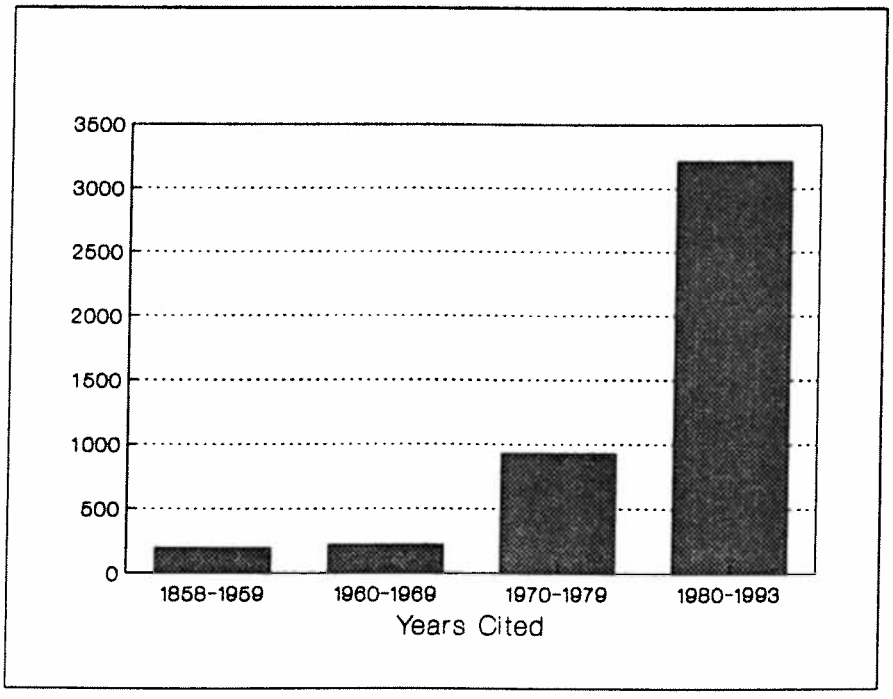
showing that most of the items cited by these academic scientists were published between 1980 and 1993. As shown on Figure 4-14, 70.58% (3,214) of the citations were to items published between 1980 and 1993. Fewer citations came from items published between 1970 and 1979, 20.31% (925), far fewer items published between 1960 and 1969 were cited by these scientists, 4.83% (220). Yet it took close to a hundred years of journal publications to yield 195 (4.28%) useful items for the study population.

These findings are similar to those of other studies. For example, Greene (1993) found that physicists at Emory University citations to journals concentrated on recent publications, 74.9% of the citations were to items published between 1980 and 1991, and 17.8% of the citations were to items published between 1970 and 1979. The remainder of the citations were spread through the rest of years cited, 1901 to 1969, clearly very similar percentages to those in this study.

Figure 4-14

Number of Items Cited by the UMB Environmental Scientists and Biologists by Publication Years

1988 to 1993



Other Publication Forms

Although the focus of this study is the journal citation patterns of the study population as means to identify the basic journal collection for these academic scientists, nevertheless, the analysis of their citation patterns reveals the use of some other publication forms that merit attention and discussion.

As shown, the study population cited books, conference proceedings and so forth. These findings are not different to those of other studies. For instance, Kelland (1990) found that ecologists and biochemists' book citations were 8.1% and 3.9% respectively of the total citations. Furthermore, his study revealed that these scientists cited different publication forms (i.e., patents) but that the percentages for these publication forms varied from 3.9% to 1.0% from the total number of cited items, similar percentages to the ones found in this study as shown on Table 4-1. Similar findings were found in Hurd's (1992) study. She found that chemists at UIC cited different publication forms. The citations to books accounted for 6.32% of the total citations, conference proceedings accounted for 1.86%, dissertations accounted for 0.88%, while the unpublished materials accounted for 1.45%, and finally the "other publication forms" accounted for 2.23% of the citations. It is clear that these findings are statistically similar to those found in this study. However, because the nature of the subject, patents were not cited by the study population of this study.

In conclusion, the UMB environmental scientists and biologists citation patterns are similar to those of other scientists. This study found that the citation patterns of the study population and those of other scientists -- as represented by *JCR* -- is statistically similar at different levels of analysis. Furthermore, the similarities between the citation patterns of the UMB environmental

scientists and biologists with those of other scientists includes citation scattering, language cited, and so forth. All of these similarities suggest that the study population might be followers of the current scientific paradigm, in other words, that they practice what Kuhn (1970) called "normal science".

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Chapter 5

IMPLICATIONS FOR COLLECTION DEVELOPMENT AT HEALEY LIBRARY

The findings presented on Chapter 4 have a significant impact on several aspects of collection development at HL. This impact will be discussed throughout this chapter in relation to the fundamental research questions raised in Chapter 1 under "Problem Statement":

- What should be the basic journal collection for the UMB environmental scientists and biologists?
- What other publication forms do the UMB environmental scientists and biologists cite?
- What journals do they cite more frequently than others?
- How do their citation patterns compare to those of other scientists?
- How does the citation frequency of the journals they cite compare to those of other scientists?
- What is the half-life of the journals they cite?
- Is the half-life of the journals they cite similar to those of other scientists?
- Do they cite journals from many subjects and how frequently do they cite these?
- How does the citation frequency of the journals they cite compare to those of other scientists (by subject category)?

These questions were incorporated into the objectives of the study, however, additional

questions were raised:

- Can JCR be a collection development tool for HL?
- Is the isomorphic method effective for comparing the rankings and the half-life of the journals cited by the study population?
- Does the present citation study of the UMB environmental scientists and biologists reveal a substantial different kind of information seeking patterns from those of other scientists? Such as citation scattering, age of the cited items, and cited publication forms that suggests a difference in these scientists needs for library resources?
- Is the current journal collection at HL efficient and effective in meeting the needs of the UMB environmental scientist and biologists?

The focus of the discussions on this chapter will elaborate on three core collection development activities identified by King (1975), Pruett (1986), and Evans (1987) that are critical to HL as well:

- acquisition;
- storage; and
- access.

However, prior to the discussions, it is necessary to introduce collection development practices and services at HL in order to place the discussion of the implications for collection development for HL in proper perspective.

Currently, HL collection development is guided by the *UMB Acquisition Policy Statement* (G). This policy establishes two major responsibilities for HL:

- meeting the university's needs for instruction and research; and
- cultural preservation.

In this policy, faculty is assigned the major responsibility for building the collection, while staff "must take the responsibility for the fields neglected by the faculty" (p. [1]). However, currently librarians are subject bibliographers that are responsible for handling book selections with a lump sum budget and "with the ultimate responsibility for the adequacy of the collection" (Grasberg, 1989, p. 61).

HL's non-serial library materials budget is managed by the Chief Bibliographer and the Acquisitions Librarian. They allocate all library material funds by department/fund account number (e.g., Biology is fund account 20). The library serials budget is handled by the Serials Librarian. HL's library collection materials budget is distributed by the Director of Libraries who receives lump-sum funding for staff, equipment, operations, and library information materials (see H).

HL access services include Circulation, Reserve, Reference, and ILL. This last service provides free of charge loans and photocopies of library resources for users through mail, FAX, and Ariel[19].

As part of its public access catalog HL offers Internet access to other area library

[19]Ariel is a software product developed by the Research Library Group that uses a personal computer, peripherals, and digital technology for the transmission text and images through the Internet. This is a recent development used for ILL and Document Delivery services.

catalogs and the Boston Library Consortium (BLC) INFOSOURCE -- this includes UNCOVER and the BLC Union List of Serials.[20] HL is a member of BLC, which grants free unlimited access to any library collection to all students, faculty or staff at any of the member academic institutions.

As to 1989 Grasberg said that (p. 64) "the problem of space does not yet represent an emergency, but it will soon require development of a long range plan". However, in 1992 the space problem reached critical level when the Downtown Campus library collection was merged with the HL collection on Harbor Campus and HL lost a floor that housed collections and services that were relocated on other floors, to this day the problems remains the same if not worse.

Implications of the General Citation Patterns on Collection Development at HL

Non-serial Publication Forms

As shown on Table 4-1 and as discussed on Chapter 4, UMB environmental scientists and biologists cited different publication forms. This supports the need for a collection development policy that guides the acquisition of these different publication forms or that can guide access services to those less cited sources (Evans, 1987; Gorman and Howes, 1989; Pruett, 1986). However, HL does not have a policy, yet with the data

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[20]UNCOVER is a journal index and Table of Contents service from the Colorado Alliance of Research Libraries. The BLC union list of serials is a database of the journals held by consortium members.

of this study a policy guiding format selection for the study population can be started (Bryant, 1988; Lockett, 1989).

Table 4-1 pointed out the different publication forms cited by the UMB environmental scientists and biologists. Yet, further examination of the data revealed that books cited by these scientists did not conform to any clear patterns. In other words, this researcher did not detect specific trends in the books cited. Therefore, this area remains open for further research.

In addition to books, these scientists cited reports, dissertations, proceedings, and unpublished sources. As with citations to books, there were no trends found in the citations to these other publication forms.

Nevertheless, the citation patterns of the UMB environmental scientists and biologists to these non-serial publication forms provides a framework for collection development at HL. For example, the few citations to dissertations and other publication forms (see Appendix B for definitions) support that these scientists require several information sources -- as represented by each publication form -- yet this dictates that HL either must own a small number of these or that it should provide access to these publication forms as requested (Evans, 1987; Gould and Pearce, 1991; Martin, 1985, Martin, 1989; Woodsworth, 1991). On the other hand, the findings show that proceedings and reports are of slightly higher significance to the UMB environmental scientists than they are to UMB biologists. Therefore, the collection development policy must include provisions for ownership or access to these materials (Hanson, 1973; King, 1976; Pruett, 1986). Due to the absence of any clear citation patterns to these publication forms this

should be an area for HL to investigate further.

One thing is clear, however, HL should not attempt to collect reports, proceedings, and other publication forms randomly. It should attempt to identify potential needs from their scientists (Pruett, 1986) on publications other than books and journals, so that these forms can also be included as an integral parts of the collection development policy and selection practices at HL (Gorman and Howes, 1989; Hall, 1985).

Furthermore, the data suggests that drastically reducing or "killing" the book budget to cope with journal subscription price increases or with sudden reductions in the library materials budget will have a negative impact on the effectiveness of the library to satisfy these scientists needs (Shrevees, 1991). Using the citation patterns found in this study it is recommendable to maintain a minimal library material budget allocation of at least 10% for monographs or books for these scientists (Devin and Kellog, 1990; Martin, 1985). However, the citation patterns of scientists should be used to restructure the traditional fund allocations at HL (Baker and Lancaster, 1991). Additional study is required to identify the specific subject areas to be met by this minimal allocation. Fund allocation implications are to be further elaborated under the "Expenditures, Budget and Fund Allocations" section on this chapter.

Basic Journal Collection

As shown by this study, journals are the most important formal information exchange vehicle for the study population. Therefore, it is a mandate that HL's collection development policy delineates this importance -- as it must include an evaluation mechanisms to identify shifts in the core journals (Broadus, 1977; Chen, 1972; Evans,

1987; Stueart, 1985; Subramanyan, 1980).

In addition to this finding, this study shows the core journals cited by these scientists. As Hall (1985, p. 55) said:

> The principle underlying citation studies is Bradford's law of scattering, which postulates that a small core of journals will publish the great majority of articles in a discipline and that the remainder will be scattered in a large number of journals. Those less directly related to the specific discipline will publish fewer relevant articles. Thus if you can determine the core journals for a discipline, you can likely satisfy a majority of the demands of researchers in that subject by collecting the core journals.

Therefore, the basic journal collection for the environmental scientists and biologists is listed on Table 4-2 and Table 4-5, and as they are further examined on the different tables throughout this chapter.

Lancaster (1988) in discussing journal citation scattering identified the third zone of scattering as the area where the library can focus it efforts to eliminate the seldom cited journals. He said that the first scattering zone is an area where very few of no disagreements must exist between the library holdings and the cited journals, as noted before, HL needs to improve its holdings of the core journals in that first scattering zone. For example, *Biotropica*, a journal cited 27 times by the UMB biologists but not owned by HL, needs to be acquired.

Table 4-2 includes journals that were cited five times only, yet these journals might be potential candidates for deselection and for access only via FAX or other services especially when cost is a consideration (Stankus and Mills, 1992). This table also points out to journals cited -- within the basic journal collection -- not held at HL that are immediate candidates for selection. A list of potential candidates for

subscriptions at HL are included on Table 5-1.

Table 5-1

Journals Frequently Cited by UMB Environmental Scientists (E) and Biologists (B) Not Owned by Healey Library

Cited Journal	Citing Group	Citation Frequency
Annals of the Entomological Society of America	B	7
Biological Oxidation Systems	B	13
Biotropica	B	27
Crop Science	B	6
Endeavour	B	9
Experimental Eye Research	B	8
Gamete Research	B	7
Investigative Ophthalmology and Visual Science	B	25
Journal of Industrial Microbiology	E	25
Journal of Molluscan Studies	B	10
Journal of Neurocytology	B	9
Kulturfplanzen	B	9
Maize Genetics Cooperation Newsletter	B	6
Malacologia	B	15
Oceanologica Acta	B	7
Oceans	E	5
Sea	B	8
UCLA Symposia in Molecular and Cellular Biology	B	18
Zoologica Scripta	B	6

The second scattering zone, as Lancaster points out, is an area where less agreement is expected between library holdings and cited journals. It is in this second and third zones that the library must concentrate on to evaluate its holdings so it can identify journals that are seldom cited and that do receive little in-house use. These journals are candidates for deselection, weeding, or access through ILL or DD as

suggested by Lancaster (1988) and many other authors.

Based on this recommendation HL should direct its collection development expenditures and collecting efforts on the core journals listed on Table 4-2. This table is a good list for examining the adequacy of HL's journal collection for the study population. As Baker and Lancaster (1991, p. 48) said:

> Once the initial list of citations has been complied, the library can determine the percentages of titles held to measure collection adequacy or can use the list of titles cited often but not held as a list of possible purchases.

HL's journal collection holds most of the core journals, shown on Table 4-2, cited by the study population (72%). Yet, the percentages of all journals cited, Appendix C, and held at HL was lower -- only 41% for the environmental scientists, and 54% for the biologists. This finding indicates that these researchers do not rely exclusively on HL for gaining access to published sources. This seems to contradict what Baker and Lancaster (1991 p. 53) implied when they said:

> In selecting the initial citations, special care must be take to avoid biasing the citation study in favor of the library. This happens when the library limits its list of citations to works prepared by scholars conducting research at that institution ... A number of studies, however, have shown that selection of information sources is based to a large extent on the accessibility of that source, with the most accessible source being chosen first. This means that libraries are more likely to have larger percentages of materials cited by researchers at their own institutions than materials cited by the general population of researchers in specific subject area.

The large number of journals cited by these scientists not available at HL suggests that they possibly rely on other information providers for their needs. These providers may be peers, their own collections, other libraries, or commercial

document-delivery/information systems as suggested by Chen (1972), Hurd (1992), King (1976), Voigt (1961) and others.

The findings clearly show that the study population cited core journals not held in the library, yet, it holds a good percentage of core journals (72%). On the other hand, other researchers found higher journal ownership percentages. One example of this is Hurd (1992) that found that 82% of the citations made by the chemists in her study were to journals in her library, while other studies have found higher percentage -- as high as 92% or over --library ownership of core journals. Based on the findings of this study HL must formulate a collection development policy with goals, objectives, and collecting levels that specify the percentage of core journals is desirable and attainable in the collection with the current budget (Bryant, 1988; Evans, 1987; Lockett, 1989, Martin, 1989). Nevertheless, as a first step, HL should acquire highly cited journals not owned (Baker and Lancaster, 1991).

On the other hand, all sources cited and listed in the preceding and following tables are not exclusively journals. Closer examination of these tables and Appendix C reveals that a number of *Annals*, *Annuals*, and *Advances* sources that even due to their low citation frequency are core items that must be kept in the collection (Pruett, 1986). Many scientists with limited time for reading, browsing, and conducting comprehensive searches need sources of this type to keep abreast with the development of their discipline as well as for identifying relevant cited items from the bibliographies included in this type of publications (Bick and Sinha, 1991; Gould and Pearce, 1991; Gray and Perry, 1975; Hanson, 1973; King, 1976).

Expenditures, Budget, and Fund Allocation

These days libraries face more financial constrains and increasing competition within their own institutions for scarce resources. This mandates a justification from librarians of all their expenditures providing effective services and collections with less resources (Chen, 1976; Chen, 1978; Morse, 1968). Such is the case of HL. Clearly, the findings will have a major financial impact on journal collection development expenditures at HL.

Baker and Lancaster (1991) in discussing citation analysis studies and resource allocation said that (p. 49): "Information such as this may be used to redistribute acquisitions budget...". The cost of the subscriptions to all core journals cited by the UMB environmental scientists and biologists as shown on Table 4-2 totals $108,973.71, a much lower figure than the current $190,427.12 journal subscription expenditures for the Environmental Sciences Program and the Biology Department.

Appendix I and Appendix J show the current list of journals acquired by HL for the UMB environmental scientists and biologists, respectively. These list show current journal expenditures by title as they also show journals purchased for these scientists per their request.

Thus additional savings are feasible by examining the citation scattering zones II and III and identifying subscriptions that can be cancelled -- based on, for example, cost, relevancy, and availability elsewhere -- that can be made physically available to these scientists through other access services such as commercial document delivery (DD) (Stankus and Mills, 1993; Woodsworth, 1991). For example,

Hydrobiologia is an expensive and seldom cited title -- cited five times in five years with a 1993 subscription price of $4,186.00 -- that could be considered for DD or FAX-access only.

Table 5-2 to 5-4 contain a wealth of information enabling HL to consider many significant areas in relation to the effective journal collection at UMB for the environmental scientists and biologists. Table 5-2 lists all the core journals cite by both the UMB environmental scientists and biologists with more detailed information other than subscription cost of each journal, such as cost per citation, number of citations per year and total citation frequency. Tables 5-3 and 5-4 list the core journals cited more than five times in the last five years by the UMB environmental scientists and biologists respectively.

Table 5-2

Core Journals Cited by UMB Environmental Scientists and Biologists Subscription/Citation Costs with Citation Frequency

Journal Cited	Subscription Cost (1993)	Cost per citation	Citations per year	Citation Frequency	Citation Frequency	Total Citation Frequency
American Naturalist	170.00	18.08	9.4	7	40	47
Applied and Environmental Microbiology	299.00	14.24	21	49	56	105
Biochemical and Biophysical Research Communications	996.00	292.94	3.4	6	11	17
Biochemical Journal	1,695.00	235.41	7.2	24	12	36
Biochimica et Biophysica Acta	7,332.00	814.66	9	12	33	45
Deep Sea Research	2,356.00	203.10	11.6	11	47	58
Ecology	97.00	10.77	9	15	30	45
European Journal of Biochemistry	2,196.00	457.75	4.8	12	12	24
Experientia	570.00	167.64	3.4	5	12	24
FEBS Letters	3,192.00	130.82	24.4	10	112	122

Geochimica et Cosmochimica Acta	640.00	118.51	5.4	21	6	27
Journal of Biological Chemistry	840.00	25.75	33.4	16	115	167
Journal of Experimental Marine Biology and Ecology	1,843.00	579.94	3.2	8	8	16
Journal of General Microbiology	780.00	150.00	5.2	21	5	26
Journal of Marine Research	60.00	21.95	3.2	11	5	16
Journal of the Marine Biological Association of the United Kingdom	329.00	96.76	3.4	6	11	17
Limnology and Oceanography	160.00	17.77	9	24	21	45
Marine Biology	2,450.00	240.20	10.2	22	29	51
Marine Ecology Progress Series	2,384.00	192.30	12.4	22	40	62
Marine Environmental Research	465.00	94.62	5.2	20	6	26
Microbial Ecology	242.00	44.81	5.4	20	7	27
Nature	395.00	18.29	21.6	22	86	108
Oceanologica Acta	283.00	103.87	2.8	7	7	14
Oecologia	2,468.00	362.94	6.8	11	23	34
Proceedings of the National Academy of Science US	420.00	50.00	8.4	5	37	42
Total	32,662.61	4,463.12	23.88	387	771	1,158

Table 5-3

Core Journals for UMB Environmental Scientists and Subscription/Citation Costs with Citation Frequency

Cited Journal	Subscription Cost (1993)	Cost per Citation	Citations per year	Total citation frequency
Advances in Organic Geochemistry	-	-	2.8	14
Agricultural and Biological Chemistry	450.00	112.50	4	20
Analyst	662.00	367.77	1.8	9
Analytical Chemistry	415.00	259.37	1.6	8
Annals of the New York Academy of Science	2,850.00	2,375.00	1.2	6
Antonie Van Leeunwenhock Journal of Microbiology	525.00	291.66	1.8	9
Applied Microbiology	1,648.00	588.57	2.8	14
Aquatic Toxicology	723.00	401.66	1.8	9

Archives of Environmental Contamination and Toxicology	479.00	342.14	1.4	7
Archives of Microbiology	1,915.00	330.17	5.8	29
Botanica Marina	789.50	789.50	1	5
Bulletin of Environmental Contamination and Toxicology	379.00	379.00	1	5
Canadian Journal of Biochemistry	90.00	75.00	1.2	6
Canadian Journal of Fisheries and Aquatic Sciences	360.00	163.63	2.2	11
Canadian Journal of Microbiology	241.00	120.50	2	10
Chemico-Biological Interactions	829.00	414.50	2	10
Chemosphere	1,264.00	25.28	5	25
Development and Industrial Microbiology	-	-	1.6	8
Environmental Science and Technology	444.00	37.00	12	60
Environmental Technology Letters	-	-	1.4	7
Environmental Toxicology and Chemistry	495.00	495.00	1	5
Estuarine, Coastal and Shelf Science	534.00	534.00	1	5
FEMS Microbiology Ecology	449.00	204.09	2.2	11
International Biodeterioration Bulletin	510.00	510.00	1	5
Journal of Bacteriology	385.00	113.23	3.4	17
Journal of Industrial Microbiology	769.00	153.94	5	25
Journal of the Fisheries Research Board of Canada	135.00	112.50	1.2	6
Marine Pollution Bulletin	376.00	64.82	5.8	29
Mutation Research	4,602.00	3,287.14	1.4	7
Mycologia	90.00	75.00	1.2	6
Oceans	19.95	19.95	1	5
Oceanus	35.00	35.00	1	5
Organic Geochemistry	520.00	123.80	4.2	21
Planta	1,915.00	1,915.00	1	5
Science of the Total Environment	2,387.00	1,491.87	1.6	8
Toxicological Assessment	-	-	1	5
Toxicology and Applied Pharmacology	762.00	762.00	1	5
Total	29,272.16	17,650.59	90.2	451

Table 5-4

Core Journals for UMB Biologists and Subscription/Citation Costs with Citation Frequency

Cited Journal	Subscription Cost (1993)	Cost per Citation	Citations per year	Total citation frequency
Advances in Insect Physiology	-	-	11.2	56
Advances in Microbial Ecology	-	-	1	5
American Anthropologist	85.00	85.00	1	5
American Antiquity	115.00	31.94	3.6	18
American Journal of Botany	155.00	20.39	7.6	38
Analytical Biochemistry	1,208.00	464.61	2.6	13
Annals of Botany	384.00	384.00	1	5
Annals of the Entomological Society of America	150.00	107.14	1.4	7
Annals of the Missouri Botanical Garden	100.00	41.66	2.4	12
Annual Review of Biochemistry	49.00	35.00	1.4	7
Annual Review of Ecology and Systematics	47.00	8.10	5.8	29
Annual Review of Entomology	47.00	33.57	1.4	7
Archives of Biochemistry and Biophysics	1,224.00	1,224.00	1	5
Archives of Insect Biochemistry	573.00	21.87	26.2	131
Biochemistry US	1,186.00	123.54	9.6	48
Biological Journal of the Linnean Society	618.00	257.50	2.4	12
Biological Oxidation Systems	-	-	2.6	13
Biology of Reproduction	160.00	88.88	1.8	9
Bioorganic Chemistry	191.00	16.75	11.4	57
Biosciences	125.00	104.16	1.2	6
Biotropica	75.00	13.88	5.4	27
Boletin del Seminario Arqueologico	-	-	1	5
Botanical Museum Leaflets Harvard University	-	-	1	5
Cell	295.00	35.97	8.2	41
Cell and Tissue Research	2,638.00	599.54	4.4	22
Comprehensive Insect Physiology	2,650.00	697.36	3.8	19
Crop Science	92.00	76.66	1.2	6
Developmental Biology	1,308.00	297.27	4.4	22
Economic Botany	70.00	19.44	3.6	18
EMBO Journal	625.00	148.80	4.2	21
Endeavor	120.00	60.00	2	10

European Journal of Cell Biology	420.00	350.00	1.2	6
Evolution	150.00	16.66	9	45
Experimental Cell Research	1,221.00	381.56	3.2	16
Experimental Eye Research	870.00	543.75	1.6	8
Federation Proceedings	-	-	1.2	6
Gamete Research	430.00	307.14	1.4	7
Heredity	305.00	254.16	1.2	6
Hydrobiologia	4,186.00	4,186.00	1	5
Insect Biochemistry and Molecular Biology	688.00	35.10	19.6	98
Journal of Cell Biology	440.00	66.66	6.6	33
Journal of Comparative Physiology	966.00	230.00	4.2	21
Journal of Comparative Physiology A	1,822.00	759.16	2.4	12
Journal of Ecology	335.00	152.27	2.2	11
Journal of Experimental Biology	935.00	311.66	3	15
Journal of General Physiology	210.00	105.00	2	10
Journal of Heredity	112.00	112.00	1	5
Journal of Insect Physiology	688.00	132.31	5.2	26
Journal of Investigative Dermatology	320.00	200.00	1.6	8
Journal of Investigative Ophthalmology and Neuroscience	200.00	40.00	5	25
Journal of Molecular Biology	379.00	210.55	1.9	9
Journal of Molluscan Studies	160.00	80.00	2	10
Journal of Neurocytology	750.00	416.66	1.8	9
Journal of Paleontology	99.00	99.00	1	5
Journal of the Chemical Society Chemical Communications	836.00	597.00	1.4	7
Journal of the Chemical Society	1,055.00	229.35	4.6	23
Journal of Ultrastructure Research	265.00	82.81	3.2	16
Kulturfplanze	-	-	1.8	9
Malacologia	35.00	11.66	3	15
Methods in Enzymology	-	-	2.6	13
Molecular and Cellular Biochemistry	2,370.00	911.54	2.6	13
Molecular and Cellular Biology	379.00	210.55	1.8	9
Nucleic Acids Research	1,100.00	177.42	6.2	31
Oikos	415.00	259.37	1.2	6
Organic Preparations and Procedures International	110.00	61.11	1.8	9
Plant Molecular Biology	1,276.00	920.00	2.2	11

Quarterly Review of Biology	80.00	57.14	1.4	7
Quaternary Research	218.00	218.00	1	5
Revista del Museo Nacional del Peru	-	-	2	10
Science	205.00	11.02	18.6	93
Sea	19.94	12.46	1.6	8
Synthesis Stuttgart	695.00	579.16	1.2	6
Systematic Zoology	60.00	50.00	1.2	6
Tetrahedron	3,987.00	1,423.93	2.8	14
Theoretical and Applied Genetics	1,897.00	862.27	2.2	11
UCLA Symposia in Molecular and Cellular Biology	-	-	3.6	18
Vision Research	1,081.00	284.47	3.8	19
Zeitschrift fur Naturoforschung C	413.00	340.00	2.4	12
Zoologica Scripta	364.00	303.33	1.2	6
Total	46,858.94	14,071.49	269.5	1,446

The total subscription cost of all journals included in Table 5-2 to 5-4 is $108, 973.71. This represent a saving of $81,453.41 over the current journal expenditures for the UMB Environmental Sciences Program and the Biology Department. In addition, the these tables show that the cost per citation varied substantially as proportional to the number of times cited and the subscription price. Close examination of these costs per citation raises additional questions regarding what is indeed a "sustainable" basic journal collection for these scientists (Stankus and Mills, 1992). Following the methodology presented by Stankus and Mills combined with an examination of other hidden costs associated with journal subscriptions or library operations, such as storage and handling (Bommer and Chorba, 1982), and compared to the costs of FAX-access only for these titles, may surface more fully what is cost-effective for the library and convenient for its users. (Martin, 1985; Martin, 1989). Stankus and Mills (1992) also examine other

variables -- such as changes and growth in the fields and journals themselves -- that must be taken into account when determining the "sustainable" basic journal collection in any science discipline.

As discussed earlier, HL journal holdings can satisfy less than half of the citation needs of the study population, thus, HL holdings must to be revised accordingly with the findings of the study. In other words, HL must acquire some journals not held at HL (Table 5-1), while other journals held at HL are potential candidates for deselection since they have not been cited during the study period (Tables 5-5 and 5-6). However, how these scientists became aware of the sources they cited and how they track the items they need remains unknown to HL librarians, this deserves to be further investigated so that more significant information for collection development can be obtained.

HL also needs to determine the service level the library must provide to these scientists. In other words, HL cannot own and provide unlimited access to all the journals that these scientists may need occasionally or that they will want to have. It desirable that HL librarians determine the percentage of journals the library can own and provide access to within the library resources, fiscal or physical (Baker and Lancaster, 1991; Lancaster, 1988; Stankus and Mills, 1992; Yocum, 1989). The current acquisitions policy does not determined the level of service attainable nor it includes collecting levels as it required for establishing collection goals and objectives or measuring the effectiveness of the collection (Bryant, 1988; Lockett, 1989).

Table 5-5

Current Subscriptions at the Healey Library For the UMB Environmental Scientists Not Cited

1988-1993

Journal Title	1993 Subscription Cost
Atmospheric Environment	N/A
Biological Trace Elements	405.00
Boundary-Layer Meteorology	1,114.58
Commercial Fisheries News	18.00
Computers and Fluids	985.00
Continental Shelf Research	760.00
Dynamics of Atmospheres and Oceans	461.00
Earth and Planetary Science Letter	1,366.00
Ecology Law Quarterly	48.00
Ecotoxicology and Environmental Safety	351.00
Environmental Action	40.00
Environmental Ethics	31.00
Environmental Forum	50.00
Environmental History Review	30.00
Environmental Policy and Law	248.07
Environmental Pollution	1.250.00
Environmental Software	330.00
Environmental Toxicology and Water Quality	195.00
EPA Journal	7.50
Biogeochemical Cycles	185.00
Hazardous Waste and Hazardous Materials	162.00
Indian Academy of Sciences. Proceedings. Earth and Planetary Sciences	75.00
International Journal of Environmental Analytical Chemistry	3,144.00
International Revue der Gesamten Hydrobiologie	445.00
Journal of Atmospheric Chemistry	368.74
Journal of Chemical Technology and Biotechnology	595.00
Journal of Chromatographic Science	190.00
Journal of Environmental Education	63.00

Journal of Fish Diseases	437.00
Journal of Fluids Mechanics	1,197.00
Journal of Invertebrate Pathology	392.00
Journal of Lipid Research	262.00
Journal of Liquid Chromatography	1,350.00
Journal of Maritime Law and Commerce	105.00
Journal of the IES	30.00
Marine Affairs Bibliography	95.00
Marine Fish Management	87.50
Marine Mammals News	67.50
Marine Policy	371.97
Marine Resource Economics	100.00
Maritime Policy and Management	307.00
Mass Spectrometry Reviews	350.00
Microchemical Journal	306.00
Natural Resources and Environment	23.00
Natural Resources Journal	32.00
Naval War College Review	N/A
Ocean and Coastal Management	565.00
Ocean Science News	365.00
Resource and Energy Economics	271.00
Sea Frontiers	24.00
Water Environment and Technology	198.00
Water Resources Research	660.00
Xenobiotica	821.00

Table 5-6

Current Subscriptions at the Healey Library for the UMB Biologists Not Cited

1988-1993

Journal Title	1993 Subscription Cost
American Biology Teacher	50.00
American Birds	35.00
American Journal of Primatology	894.00
Arnoldia	20.00
Behavioral and Brain Sciences	210.00
Behavioral Ecology	147.00
Behavioral Ecology and Sociobiology	1,066.00
Biodegradation	230.00
Biologia Plantarum	249.47
Biological Conservation	830.00
Biometrics	90.00
Biometrika	124.00
Bird Observer	16.00
British Museum (Natural History) Bulletin. Botany	125.71
British Museum (Natural History) Bulletin. Zoology	133.00
Copeia	90.00
Development, Growth and Differentiation	210.00
Differentiation	999.00
Diversity	55.00
Endocrine Reviews	110.00
Environmental Entomology	150.00
Ethos and Sociobiology	324.00
Journal of the Federation of American Societies for Experimental Biology	275.00
Genetica	429.16
ICES Journal of Marine Sciences	177.00
Immunology and Cell Biology	215.00
In Vitro Cellular and Developmental Biology. Animal	300.00

International Union for the Conservation of Nature and Natural Resources. Membranes	55.00
Journal of Biogeography	486.00
Journal of Biological Education	103.00
Journal of Endocrinology	470.00
Journal of Eukaryotic Microbiology	134.00
Journal of Horticultural Science	170.00
Journal of Microbiological Methods	505.00
Journal of Nutrition	185.00
Journal of Structural Biology	295.00
Journal of the History of Biology	172.91
Journal of Virology	380.00
Laboratory Investigation	233.00
Lipids	215.00
Marine Mammal Science	100.00
Methods	N/A
Natural History	28.00
Neuron	350.00
Oncogene	998.43
Perspective in Biology and Medicine	60.00
Physiological Zoology	200.00
Plant Molecular Biology Reporter	170.00
Plasmid	208.00
Protoplasma	1,603.00
Reproduction, Fertility and Development	195.00
Review of Agricultural Entomology	658.00
Rhodora	45.00
Roux's Archives of Developmental Biology	700.50
Royal Society of Edinburgh. Proceedings. Section B	N/A
Species	18.00
Taxon	108.00
Transplantation	370.00
Virology	1,200.00

The findings imply that current expenditures can be redirected to acquire journals frequently cited but not owned at HL or to satisfy other journal requests (Shrevees, 1991). To be able to do this HL librarians need to deselect some journals from Table 5-5 and 5-6. However, a word of warning is necessary. It is important to determine whether other constituencies at UMB use or cite these journals (Bensman, 1985; Devin and Kellog, 1990; Hurd, 1992; Kelland, 1990).

Finally, the journal and book citation ratio found in this study could be used for budget fund allocation at HL as well. Devin and Kellog (1990) proposed a fund allocation formula based on citation studies. The formula devised by these authors uses the percentages of journal citations studies directly to device a serial(S)/monograph(M) ratio. The calculations discussed by these authors and summarized in two formulas:

$$S = \frac{(M)(\%)}{(100 - \%)}$$

$$M = \frac{S}{\%} - S$$

This formula, according to the authors, only establishes the ratio between serials and monographs, it does not take into account collecting intensities or levels that have to be applied after the ratio has been determined.

JCR and Collection Development at HL

The ranking order of journals cited by the UMB environmental scientists and biologists was found not to resemble that of *JCR*. Yet, when this researcher correlated the rankings of those journals with the corresponding rankings of the same group of journals in *JCR*, a good correlation was found. Stankus and Rice (1987) had similar

findings when they grouped the journals by subject category. They concluded that *JCR* impact factors are a good indicator for assessing a journal collection for selection and deselection. Yet, this researcher found that the rankings of the journals cited by the UMB environmental scientists and biologists did not correlate as well with the impact factors of the journals. There were different correlation values that yielded from no to high correlation without producing clear distinctive patterns. Contrary to the expectations, the citation patterns of the study population do not always conform to the citation patterns of other scientists when the journals were group by subject category.

Thus, the study only partially supports the believe that impact factors are measures -- as citation frequency ranking -- for journal evaluation, but not a definite measure of journal worth as discussed on Chapter 2. Specifically, the findings suggest that citation frequency can be used for assessing the potential value of a journal for the study population. In other words, faculty's requests for new journals -- as well as current active subscriptions at UMB -- can be assessed with their citation frequency as reported in *JCR* because journals frequently cited by the other scientists have a better chance for receiving more citations by the UMB environmental scientists and biologists, and vice versa. In sum, *JCR* ranking data may be considered an important factor for journal selection and for deselection models for HL (Bensman, 1985; Bostic, 1985; Kraft, 1979; Smith, 1985), despite of a wide range of conflicting views as discussed on Chapter 2.

The Spearman's rho test showed that the ranking of the journals cited by the UMB environmental scientists and biologists were similar to those of *JCR*. Yet the isomorphic test between the ranking order of the journals cited by the study population and those of

JCR showed these were not similar. Therefore, despite the results of Baughman (1974) and Stankus and Rice (1987), this study seems to suggest that isomorphic method is less effective for measuring similarities in the rankings of the journals cited by different populations.

Journal Subject Categories Cited

The subject grouping of journals and the analysis of the citations by these categories yielded valuable information. For example, the findings suggest that the study population cites journals from many different subject categories and that the citation patterns for these categories are different, yet these differences might arise from the interdisciplinary nature of their research. The findings suggest that HL librarians need to move from their traditional fund allocation by department to subject categories allocations that incorporate a great deal of flexibility in the fund allocation process so they can satisfy the multi-subject information needs of the UMB environmental scientists and biologists. Table 4-5 can guide HL librarians in knowing the different journals and subjects cited by these scientists and help them to identify areas that deserve more careful attention.

The UMB environmental scientists and biologists cited journals from a large number of subjects as shown on Tables 4-3, 4-4 and 4-5. Obviously, HL cannot own every journal cited, and within the budget the library must seek to provide what its users need (Martin, 1985). The aforementioned tables can be viewed as subject guides for journal acquisition for the study population.

Overall the findings of this study suggest that HL needs to expand it collection

development responsibilities. In other words, HL needs to satisfy a group of scientists whose needs are not confined in the traditional subject boundaries (e.g., physicists, mathematicians). In order to have an interdisciplinary basic journal collection, HL librarians need to have new fund allocation strategies (Hurd, 1992). For example, changing the traditional fund allocation by department to a fund allocation using an LC classified profile of research and/or courses at UMB (Shrevees, 1991).

Storage and Access

Storage

As shown on Chapter 4, the half-life of the journals cited by the UMB environmental scientists and biologists generally are not similar to that of *JCR*. In other words, the median age of the citations made by the study population to a specific journal was different from the median age of the citations made to that same journal by the scientific community in general. For example, the UMB environmental scientist cited the *Annual Review of Microbiology* in 1991, the half-life of the citations made to that journal by these scientists was 6.4 years, the median age of the citations given to this journal as it appeared on *JCR* was of 4.0 years, a difference of over two years. Thus HL should not refer to *JCR* half-life data for determining the half-life of journals in its collection.

Nevertheless, the calculation of the half-life data of the journals cited by this study population yield valuable information on the citation patterns of these scientists. For example, although the median half-life of the journals cited varied year to year it showed that the bulk of the citations was to journals published in the last 6.5 years, so the citation patterns of these scientists are similar to that of other scientists, as conformed with Price's

(1965) findings as discussed in Chapter 4. The half-life of the journals cited by the UMB environmental scientists and biologists is consistently shorter than 10 years, as predicted by Price to be the norm for most scientists.

The median half-life of the journals cited by the study population clearly indicates that 50% of their citations were to items published in the last six to seven years. This has implications for collection development at HL. For example, this data can be used for retention schedules of journal volumes. HL is not a research library, therefore there is no mandate to collect extensively and retrospectively all journals that it subscribes to. Furthermore, retaining all volumes on the stacks is cumbersome for the user (Morse, 1968), as it reduces their chance to gain quick access to needed and known resources (Bommer and Chorba, 1982). Furthermore, to retain all journal backruns might not be efficient nor effective way for HL's limited resources. The findings of this study provide an initial framework for librarians to look at journal retention policies in the library. In other words, at least 50% of the population journal citation needs can be satisfied by retaining journal issues of the last ten years (Zimmermann, 1982). It should be noted that HL librarians should not apply this as an across-the-board policy.

Retention schedules of journal backruns should be, at best, assessed for each journal. The collection development policy must be attuned with factors such as needs, demands, use, or citation patterns. This policy must include quick and efficient access mechanisms to those journals backruns relegated or discarded (Evans, 1987).

Figure 4-13 clearly shows number of citation and the cited years. From those data it is evident that some pre-1960 volumes could be weeded from the collection with little

impact on clientele's journal citation needs and at the same time it will reduce the space problem at HL (Chen, 1976; Morse, 1968). This figure also shows that as time passes it can be expected that the largest percentage of citations to journals by these scientists will be given to materials published in the last ten years, since there is an exponential decrease of citations to journals associated with the age of the materials. In other words, it is expected that the relevancy of the data in these journals will decrease exponentially for these scientists as new advances in the field develop and are reported in newer articles (Zimmermann, 1982).

Therefore, two fundamental applications can be drawn for collection development at HL:

- HL can weed some of the pre-1960 journal volumes with little impact on user's convenience; and
- HL does not need to rely on JCR data for weeding, deselection, or storage decisions. This data should be generated internally and this will be generally more accurate than that of *JCR*.

Yet, the storage and discarding decisions of specific journals should be left to HL librarians who will have to weigh other factors in that decision making process (Evans, 1987; Stueart, 1985).

Access

Library and information science literature includes many concerns and debates regarding information access issues, specifically browsing. In American libraries, browsing is generally available to library users. Even classification systems facilitate this by allowing users to find needed information by serendipity in the subject organized stacks.

Yet, this occurrence -- finding information by browsing and serendipity -- seems to be lower than expected in scientists as shown in some studies. For example, King (1976) found that browsing played a minimal role in how scientist came across journal literature. This was confirmed by Hallmark (1994) who found that browsing ranked third in the way scientists gained access to items they cited in their publications. The findings of both studies were similar ranging from 2% to 11% for physicists, chemists, biologists, and mathematicians, with a higher percentage (26%) for geologists.

In addition to that finding, King (1976) conducted a journal tracking survey that involved -- among other scientists -- environmental scientists and biologists. He discovered that journal articles used for citations were obtained most frequently through libraries (50.8% of the times) giving more weigh to the "acquisition and storage" function, as well as to "physical access" and "information distribution" roles of libraries.

King also found that environmental scientists -- in contrast to other scientists in his study -- did not depend on library ownership of journals to gain access to cited journals. Clearly, these findings indicate that further study is required to determine how the UMB environmental scientists and biologists gain access or track journals or journal citations either at HL or elsewhere.

It can be expected that the UMB environmental scientists have has similar browsing patterns as the scientists studied by King (1976) and Hurd (1992). Therefore, the need to maintain physical and immediate access to journals by subscribing to these might not be as critical as generally perceived. Consequently, HL could rely on table of contents services, selective-dissemination-of-information-services (SDI), document

delivery services (DD), and electronic access to other information services to assists these scientist in locating information resources instead of expecting these scientists to rely on journal browsing for finding information or to use the extensive journal index collection at HL (*Information Technology and the Conduct of Research*, 1989; Woodsworth, 1991).

To this researcher's knowledge, the UMB environmental scientists and biologists receive the floppy disk version of *Current Contents* (ISI) and then it circulates among those interested. This table of contents service includes the addresses of the authors listed in the database. It can be expected that many academic scientists at UMB use this information to establish contact with peers or to request reprints and papers from those authors. In other words, the "invisible college" works well for scientists at UMB.

This phenomena also suggests the ILL services are significant in order to enable the UMB scientists to gain access and track identified journals not owned by HL.

In addition to ILL, -- and the possible use of DD, SDI and table-of-contents-services access -- HL should continue offering and expanding consortium agreements and resource sharing as a valuable complement to its journal collection for satisfying these scientists journals needs (Woodsworth, 1991).

For obvious reasons, new-information-technology (NIT) -- computer networks, full-text databases, digital telecommunications, and laserdisk technology -- has potential for access and DD services for HL as well. For example, as discussed by the Information Technology and the Conduct of Research Committee of the National Academy of Science (1989) the raising cost of information sources is a chronic problem, therefore information technology deserves a high priority for sharing information sources via electronic mail

and file transfers. Furthermore, this Committee recommends NIT as an effective support mechanism for research that universities, professional groups, and information service providers should use to provide unified access to information. Woodsworth (1991) elaborates on the current and the potential role of NIT for libraries when she points out the raising cost of journals and other information sources and places NIT in the forefront of solutions to deal with this problem with similar recommendations to those proposed by that Committee. However, NIT at HL, like in many other places, needs to be up-graded to reach this realm where data, journals, etc. can be made accessible electronically to the researchers at their desk-top.

Scientific Paradigm of the Study Population

The citation patterns of the study population are generally similar to that of other scientist, as shown throughout Chapter 4 and this chapter. They conform to Bradford's Law of Scattering. Thus, it can be assumed that the similarity of their citation patterns to those of other scientists in the "hard sciences" implies that they conform to the norms and rules of the existing scientific paradigm. In other words, the UMB environmental scientists and biologists practice "normal science" as they cite as other scientists do, as well as they communicate with other scientists through formal communications means (e.i., journals) that are part of the prevailing paradigm (Kuhn, 1970).

The findings of this study also indicate that the study population cites journals as other scientists do, therefore their needs are not unique or different. Consequently, these scientists do not require a dramatic overhaul of collection development practices at HL. The modifications required to satisfy the journal citation needs of these academic

scientists are minimal and mostly related to modern collection development practices rather than to any major shifts in library service/collection "paradigms". These scientists are indeed very similar to that of other scientists in most respect, except for the reliance on journals of different subjects which is -- as Hurd (1992) and other researchers have pointed out -- a trend in other "hard" sciences as well.

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Chapter 6

RECOMMENDATIONS FOR FUTURE RESEARCH AND CONCLUSIONS

During the course of this study the need for additional research was identified. Some of these research areas stem from the limitations and assumptions discussed on Chapters 3, others result from the limitations imposed by the selection of the study population that excluded constituencies from those two UMB departments (e.g., students) as it excluded other HL users as well.

The following questions formulated by this researcher during the investigation need to be addressed:

- What journals are used by the UMB environmental scientists and biologists and not cited and therefore are part of the basic journal collection needed for these scientists?
- What other HL users may cite or use the journals found in this study to be potential candidates for deselection and therefore could not be cancelled?
- What books and other non-serial publications forms the study population use but do not cite?
- What other non-serial publication forms do other constituencies of these two UMB departments use and cite?

- To what extent do the UMB environmental scientists and biologists rely on HL collections and services for tracking known citations and journals? Do they use their own collection? Other libraries? Do they rely on peers? Do they use DD, ILL, or other libraries?

- How did these scientists learned about the items they cited? Did they rely on browsing, indexes and abstracts, colleagues, etc.?

- What journal subscription costs can affect HL collection development decision-making for retaining current subscriptions, acquiring new subscriptions, or offering access services to those journals identified as non-core?

The following research recommendations will address these questions and complement the data from this study. These research recommendations stem from suggestions in the literature reviewed and discussed on Chapters 2, 3 and 5. It is hoped that these recommendations will address important areas left unexplored by this study. These recommendations fall into different categories:

Library Resources Use

- Study in-house use of journals at HL;
- Study ILL requests at HL; and
- Study circulation loan patterns at HL.

Citation Analysis Studies

- Study citation patterns of the UMB environmental science and biology students, including their activities related to dissertations and theses work.

Journal/Citation Tracking

- Study the journal citation tracking of

the UMB environmental scientists, biologists, and students in these departments.

Library Costs

- Study the hidden costs (e.g., stack space cost, operational costs, and staff costs) associated with handling the journals owned by HL for the UMB environmental scientists and biologists;
- Study the costs of ILL transactions for the UMB environmental scientists and biologists; and
- Study the costs of DD transactions for the UMB environmental scientists and biologists.

These studies will yield valuable information that will assist HL in making sound decisions and recommendations related to collection development. With the results yielded from these research areas HL can assess more accurately its current collection development expenditures and related operational costs (Bommer and Chorba, 1982).

These research projects will offer critical information that will assist librarians at HL in identifying journals, books, and other non-serial publication forms used or cited yet not included in this study; as well as enable librarians to reallocate HL financial resources in subject areas where citations and use are high.

To complement citation analysis studies many authors have recommended using a combination of research methodologies to assess library collections and for identifying the needs of library clients. For example, Broadus (1977) and Subramanyan (1980) suggest the use of in-house use studies of journals. HL should conduct such type of in-

house study of journals. It should also conduct a citation analysis study of other academic scientists and science students at UMB. The findings of these studies will provide HL with more complete and accurate data regarding journals acquisition and deselection .

In addition to these methodologies, Stueart (1985) suggested the use of other methodologies to assess library collections including the Delphi method for evaluating library materials. Broadus (1977) specifically recommends the use of three different methods to assess collections and users: in-house use or circulation statistics, citation analysis, and expert opinion. He points out that the combination of these three methods will give a better picture of the library needs to serve its clients.

Clearly, a variety of research projects can be conducted to address the areas left unexplored in this study. However, it is necessary to formulate these into more focused and manageable problems with implications on collection development and library services at HL.

Conclusions

In discussing the implications of the findings for collection development at HL several conclusions were drawn and discussed in the last sections of Chapter 5. This section will highlight the most relevant conclusions presented in that chapter.

As shown, citation analysis is a valid method for investigating past and current citation patterns in order to provide guidance for the future. Yet, citation analysis, like

any other methodology, cannot be used in isolation. While a citation analysis study takes place, a journal in-house use study should also be considered, so should ILL transactions. These three studies will provide more complete and useful results to assess what the library needs to serve its users. However, this three-prong approach is time consuming and labor intensive. It requires a great deal of investment from part of the researchers.

Clearly, this study has yielded valuable results that can translate into guidelines for collection development and services at HL for the UMB environmental scientists and biologists. As shown on Chapter 5 there are many implications including potential savings on journal expenditures at HL. These savings can be redirected for acquiring highly cited journals not owned by HL.

In addition, the percentage of journals and monographs found to be cited by the study population can be incorporated into the fund allocation process at HL by applying the serial/monograph ratio formula devised by Devin and Kellog (1990). Furthermore, the findings suggest that "killing" or reducing the book budget totally will affect HL ability to satisfy these academic scientists. The study shows that citations to books are as high as 10%, that this portion of the information needs cannot be ignored.

The findings also indicated that generally the citation patterns of these academic scientists are similar to that of other scientists. As shown, they cite journals more than any other publication form, and the citation frequency of the journals is statistically similar to those of other scientist as they appeared on *JCR*. On the other hand, expected differences were found between the subject citation patterns of these scientists as compared with those of other scientists. The interdisciplinary journal citations of this

study population indicate that these scientists are actively engaged on publication/research projects that require access to collections with a wide variety of journal titles and different subjects. This fact must be incorporated in HL's collection development policy. This policy should also incorporate collecting levels and intensities that equate to the citation needs of these scientists.

In addition to these findings this study identified the half-life of the journals cited by these academic scientists. From this procedure the age of the journals cited by the study population indicated that HL can solve its space problem by weeding some pre-1960 volumes with little effect on the library's effectiveness in meeting user's needs. The findings also indicated that the median age of the journals cited by the UMB environmental scientists and biologists was 6.5 years and that this trend is consistent over time, therefore, most of the journals cited will be in the last ten years further limiting the shelf-life of journals at HL. This might be used for retention and microfilm holding policies at HL.

Obviously, no library budget can satisfy every demand and need of library users and HL is no exception, yet, if the library redirects its current fund allocations to journals highly cited and not owned by HL it will increase its effectiveness. HL cannot keep the current expenditure levels on journals that are never or seldom cited. Yet additional study is required to determine the core journals and non-serial publication forms needed by these and other library users so the library can weed unnecessary resources and provide those that are required.

This study has provided invaluable information on what comprises the basic

journal collection for the study population. At the same time, the study has indicated that these scientists conform to the prevailing scientific paradigms as shown through their citation patterns. Yet new questions arise regarding the nature of this scientific paradigm of the environmental sciences, for example:

- Do academic environmental scientists have citation patterns different to other environmental scientists working in the industry?
- Do the UMB environmental scientists conform to the demands of the "academia" rather than to the prevailing paradigm in their field?

These questions merit further investigation.

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APPENDICES

APPENDIX A

DATA COLLECTION FORM

Author (include only UMB author):_____
_____
_____
_____

Author's Department Affiliation (check one):
___Biology
___Environmental Science

Source article (include full citation):_____
_____
_____
_____
_____
_____

Title of cited journal (include full title and citation):_____
_____
_____
_____
_____
_____

Publication year of cited item:_____.

Subject of cited journal (use *JCR*'s *Subject Category Listing*):

_____
_____

JCR ranking:_____ (use Alphabetical Listing of Journals and *Journals Ranked by Times Cited*).

JCR cited half-life:_____.

JCR cited half-life by subject category:_____.

UMB cited half-life for cited journal:_____.

Non-journal forms cited:

____ Books

____ Conference Proceedings

____ Reports

____ Dissertations

____ Unpublished

____ Other

APPENDIX B

DATA COLLECTION DEFINITIONS[21]

Journals:	Periodical publications with a regular frequency that contains articles and disseminate scholarly research and information.
Books:	Publications completed in one part or intended to be completed in separate parts.
Reports:	Reports concerning the results of scientific investigations. These generally include detailed information of the investigation. Generally supported by an organization.
Conference Proceedings:	A published report of a presentation on a conference meeting sponsored by and organizations (i.e.; American Chemical Society).
Dissertation:	Research paper submitted to a university for completion of an advanced degree.
Unpublished:	Materials not yet published, excluding dissertations.
Other:	Includes any publication that does not fall into any of the previous definitions. Includes handbooks, guides, atlases, newspapers, etc.

[21]The definitions are based on: ***ALA Glossary of Library and Information Science.*** (1983) Chicago, IL: American Library Association. and Chen, C. C. (1987). ***Scientific and Technical Information Sources.*** Cambridge, MA: MIT Press.

APPENDIX C

LIST OF JOURNALS CITED

Citation Frequency	Journal Cited
2	*AAPG Bulletin*
2	*ACS Symposium Series*
1	*Acta Botanica Croatia*
1	*Acta Chemica Scandinavica*
1	*Acta Hydrochimica et Hydrobiologica*
2	*Advances in Applied Microbiology*
1	*Advances in Biochemical Engineering*
1	*Advances in Botanical Research*
1	*Advances in Cancer Research*
4	*Advances in Chemistry Series*
1	*Advances in Inorganic and Radio Chemistry*
1	*Advances in Inorganic Chemistry*
3	*Advances in Inorganic Chemistry and Radiochemistry*
3	*Advances in Microbial Ecology*
1	*Advances in Microbial Physiology*
14	*Advances in Organic Geochemistry*
3	*Advances in Organometallic Chemistry*
20	*Agricultural & Biological Chemistry*
1	*American Chemical Journal*
1	*American Journal of Botany*
1	*American Journal of Clinical Pathology*
1	*American Journal of Hygiene*
7	*American Naturalist*
9	*Analyst*
3	*Analytica Chimica Acta*
4	*Analytical Biochemistry*
8	*Analytical Chemistry*
1	*Angewandte Chemie International Edition*
6	*Annals of the New York Academy of Science*
2	*Annual Review of Cell Biology*
1	*Annual Review of Energy*
2	*Annual Review of Microbiology*
1	*Annual Review of Phytopathology*
1	*Annual Review of Plant Physiology*
1	*Antarctic Science*
1	*Antonie Van Leeuwenhock International Journal General and Molecular Biology*
9	*Antonie Van Leeuwenhock Journal of Microbiology Serology*
29	*Applied & Environmental Microbiology*
13	*Applied Microbiology*
4	*Applied Microbiology and Biotechnology*
20	*Applied Organometallic Chemistry*
1	*Applied Statistics of the Royal Statistical Society*
2	*Aquaculture*
9	*Aquatic Toxicology*
1	*Archiv fuer Hydrobiologie Supplementband*
1	*Archiv fuer Mikrobiologie*
9	*Archives of Biochemistry & Biophysics*
7	*Archives of Environmental Contamination Toxicology*
29	*Archives of Microbiology*
1	*Academy of Natural Science of Philadelphia Special Publication*
1	*Acta Oecologica Oecologia Applicata*
1	*Acta Physiologica Scandinavica*
1	*Acta Vitaminologica & Enzymologica*
1	*Actas y Trabajos*
1	*Advances in Archeological Method & Theory*
2	*Advances in Enzymology*
56	*Advances in Insect Physiology*
5	*Advances in Microbial Ecology*
1	*Agricultural & Biological Chemistry (Tokyo)*
1	*Agricultural Information Bulletin U.S. Department of Agriculture*
1	*Agroforestry Systems*
1	*Agronomy Journal*
2	*Alkaloids Chemistry and Physiology*
1	*Amazonia Peruana*
4	*Ambio*
1	*America Latina Estudios de Ciencias Sociales*
1	*America Latina Estudios de Cientificos Sovieticos*
5	*American Anthropologist*
18	*American Antiquity*
1	*American Fern Journal*
3	*American Journal of Anatomy*
38	*American Journal of Botany*
1	*American Journal of Clinical Pathology*
1	*American Journal of Physiology*
3	*American Midland Naturalist*
40	*American Naturalist*
1	*American Society for Testing & Materials Technical Publications*
1	*American Zoology*
2	*Anales Cientificos de la Universidad Agraria*
5	*Analytica Chimica Acta*
13	*Analytical Biochemistry*
1	*Anatomical Record*
3	*Angewandte Chemie International Edition*
3	*Animal Behavior*
5	*Annals of Botany*
1	*Annals of the Carnegie Museum*
7	*Annals of the Entomological Society of America*
12	*Annals of the Missouri Botanical Garden*
1	*Annotationes Zoologicae*
3	*Annual Report of the Smithsonian Institution*
1	*Annual Review of Anthropology*

3	*Archives of Toxicology*
2	*Bacteriological Reviews*
6	*Biochemical & Biophysical Research Communications*
24	*Biochemical Journal*
3	*Biochemical Pharmacology*
1	*Biochemistry and Pharmacology*
1	*Biochemistry US*
12	*Biochimica et Biophysica Acta*
1	*Biodeterioration*
1	*Biological Oceanography Journal*
1	*Biological Review*
1	*Biometrika*
1	*Bioscience*
1	*Biosystems*
1	*Biotechnology and Bioengineering*
5	*Botanica Marina*
3	*British Phycological Journal*
1	*Bulletin Japanese Society of Scientific Fisheries*
4	*Bulletin Mountain Desert and Island Biological Laboratory*
2	*Bulletin of Environmental Contamination*
5	*Bulletin of Environmental Contamination & Toxicology*
4	*Bulletin of Marine Science*
1	*Bulletin of the Fisheries Research Board of Canada*
6	*Canadian Journal of Biochemistry*
3	*Canadian Journal of Botany*
1	*Canadian Journal of Chemistry*
11	*Canadian Journal of Fisheries & Aquatic Sciences*
10	*Canadian Journal of Microbiology*
2	*Canadian Journal of Zoology*
4	*Cancer Research*
1	*Cell*
1	*Cell Biology*
1	*Centre International de la Recherche Scientifique Group Francaise de Argiles Bulletin*
1	*Centre National de la Recherche Scientifique Bulletin*
1	*Chemical Geology*
1	*Chemical Review*
10	*Chemico Biological Interaction*
1	*Chemische Berichte*
25	*Chemosphere*
4	*Comparative Biochemistry and Physiology C*
2	*Comparative Biochemistry and Physiology B*
1	*Comparative Biochemistry and Physiology*
3	*CRC Critical Reviews in Microbiology*
1	*CRC Critical Reviews in Toxicology*
4	*Current Microbiology*
1	*Cytobiologie*
1	*Cytobios*
11	*Deep Sea Research*
8	*Development & Industrial Microbiology*
7	*Annual Review of Biochemistry*
29	*Annual Review of Ecology & Systematics*
7	*Annual Review of Entomology*
2	*Annual Review of Genetics*
3	*Annual Review of Microbiology*
1	*Annual Review of Plant Physiology*
2	*Anthropological Papers Museum of Anthropology University of Michigan*
1	*Anthropological Papers of the University of Arizona*
1	*Antiquity*
1	*Antropologia Andina*
1	*Antropologia e Historia*
1	*Antropologia e Historia Epoca 2*
56	*Applied & Environmental Microbiology*
1	*Aquaculture*
1	*Aquatic Toxicology*
1	*Archeology*
1	*Archive of Biochemistry and Biophysics*
1	*Archives de Zoologie Experimentale et General*
5	*Archives of Biochemistry and Biophysics*
1	*Archives of Environmental Contamination & Toxicology*
131	*Archives of Insect Biochemistry & Physiology*
2	*Archives of Microbiology*
1	*Arqueologia y Sociedad*
1	*Astarte*
2	*Australian Journal of Botany*
1	*Australian Journal of Marine & Freshwater Research*
1	*Bayer Symposia*
1	*Behavioral Ecology and Sociobiology*
1	*Berichte del Deutschen Botanischen Gessellschaft*
11	*Biochemical & Biophysical Research Communications*
1	*Biochemical Genetics*
12	*Biochemical Journal*
4	*Biochemical Pharmacology*
3	*Biochemistry Journal*
48	*Biochemistry US*
33	*Biochimica et Biophysica Acta*
1	*Biogeographica*
3	*Biologia Generalis*
4	*Biological Bulletin*
2	*Biological Chemistry Hoppeseyle*
12	*Biological Journal of the Linnean Society*
13	*Biological Oxidation Systems*
2	*Biological Reviews*
3	*Biology Journal of the Linnean Society*

1	*Doklady Akademii Nauk USSR*
2	*Drug and Metabolism Disposition*
2	*Earth and Planetary Science letters*
4	*Ecological Monographs*
15	*Ecology*
1	*Environmental Biogeochemistry*
2	*Environmental Chemistry*
2	*Environmental Health Perspective*
1	*Environmental Management*
2	*Environmental Monitoring and Assessment*
1	*Environmental Pollution*
1	*Environmental Quality Supp 3*
60	*Environmental Science & Technology*
7	*Environmental Technology Letters*
5	*Environmental Toxicology & Chemistry*
2	*Estuarine and Coastal Marine Sciences*
5	*Estuarine, Coastal & Shelf Science*
1	*Estuarine, Costal and Shelf Management*
5	*European Journal of Applied Microbiology & Biotechnology*
12	*European Journal of Biochemistry*
1	*European Journal of Cell Biology*
1	*European Journal of Pediatrics*
5	*Experientia*
1	*Experimental Cell Research*
3	*Experimental Mycology*
10	*FEBS Letters*
1	*Federation Proceedings*
11	*FEMS Microbiology Ecology*
2	*Fisheries Bulletin*
1	*Fresinius Journal of Analytical Chemistry*
1	*Fresinius Zeitschrift fur Analytische Chemie*
1	*Functional Ecology*
1	*Fundamental and Applied Toxicology*
1	*Fungicide*
21	*Geochimica et Comochimica Acta*
1	*Geological Society of America Memoirs*
1	*Geology*
2	*Geomicrobiology Journal*
1	*Geophysical Monographs*
3	*Helgolander Wissenschaftlich Meeresuntershchunger*
2	*Histochemistry*
1	*Hoppe-Seyler's Zeitschrift fuer Physiologie Chemie*
3	*Hydrobiologia*
1	*Indian Journal of Experimental Biology*
1	*Industrial Journal of Microbiology*
3	*Inorganica Chimica Acta*
5	*International Biodeterioration Bulletin*
1	*International Journal of Environmental Analytical Chemistry*
2	*International Journal of Systematic Bacteriology*
1	*International Review of Cytology*
9	*Biology of Reproduction*
57	*Bioorganic Chemistry*
1	*Biophysics of Structure & Mechanism*
6	*Bioscience*
1	*Biotechnology and Ecology*
27	*Biotropica*
1	*Bird Banding*
1	*Boletin de la Sociedad Argentina de Botanica*
1	*Boletin de Lima*
3	*Boletin del Museo Arqueologico de la Serena*
1	*Boletin del Museo de Historia Natural Javier Prado*
5	*Boletin del Seminario Arqueologico*
1	*Boletin Malacologico*
1	*Boletin Sociedad Botanica de Mexico*
1	*Bolletino Malacologico*
1	*Botanical Gazette*
2	*Botanical Journal of the Linnean Society*
5	*Botanical Museum Leaflets Harvard University*
3	*Botanical Reviews*
1	*Brenesia*
4	*Brittonia*
2	*Brookhaven Symposia in Biology*
1	*Bulletin Centre d'Etudes Recherche Scientifique*
1	*Bulletin d'Institute Francaise d'Estudes Andines*
1	*Bulletin de la Societe d'Anthropologie Paris*
2	*Bulletin du Museum National d'Histoire Naturelle*
2	*Bulletin Field Museum of Natural History*
1	*Bulletin Museu Paraense*
1	*Bulletin Museum d'Historie Naturelle Paris*
2	*Bulletin Museum of Comparative Zoology Harvard University*
1	*Bulletin of Marine Science*
2	*Bulletin of the Biological Society of Washington*
1	*Bulletin of the Botanical Museum of Harvard University*
1	*Bulletin of the California Academy of Science*
1	*Bulletin of the Chemical Society of Japan*
1	*Bulletin of the Missouri Botanical Garden*
1	*Bulletin of the Museum of Comparative Zoology Harvard University*
1	*Bulletin of the Museum of Science & Art*
3	*Bulletin of the Torrey Botanical Club*

2	*International Revue der Gesamten Hydrobiologie*
1	*Investigacion Pesquera*
2	*Journal de Conseil International pour l'Exploration de la Mer*
13	*Journal of Agricultural & Food Chemistry*
1	*Journal of Analytical Toxicology*
2	*Journal of Applied Bacteriology*
2	*Journal of Applied Biochemistry*
4	*Journal of Applied Chemistry*
1	*Journal of Applied Polymer Science*
17	*Journal of Bacteriology*
1	*Journal of Basic Microbiology*
4	*Journal of Biochemistry*
16	*Journal of Biological Chemistry*
3	*Journal of Cell Biology*
2	*Journal of Chemical and Engineering Data*
1	*Journal of Chromatography & Biomedicine*
2	*Journal of Dentistry Research*
2	*Journal of Electron Microscopy*
8	*Journal of Experimental Marine Biology and Ecology*
2	*Journal of Fermentation Technology*
3	*Journal of General and Applied Microbiology*
21	*Journal of General Microbiology*
1	*Journal of General Physiology*
1	*Journal of Geophysical Research Oceans*
2	*Journal of Geophysical Research*
2	*Journal of High Resolution Chromatography*
4	*Journal of Histochemistry and Cytochemistry*
25	*Journal of Industrial Microbiology*
1	*Journal of Lipid Research*
11	*Journal of Marine Research*
1	*Journal of Membrane Biology*
2	*Journal of Neurochemistry*
3	*Journal of Organometallic Chemistry*
3	*Journal of Organometallic Chemistry Library*
1	*Journal of Parasitology*
2	*Journal of Phycology*
1	*Journal of Physical Oceanography*
4	*Journal of Plankton Research*
3	*Journal of Protozoology*
1	*Journal of Soil Science*
2	*Journal of the American Chemical Society*
1	*Journal of the Chemical Society Chemical Communications*
6	*Journal of the Fisheries Research Board of Canada*
6	*Journal of the Marine Biological Association of the United Kingdom*
1	*Journal of Theoretical Biology*
1	*Journal of Toxicology and Environmental Health*
1	*Kiel Meeresforschungen*
1	*Lecture Notes in Coastal and Estuarine Studies*
1	*Lethaia*
1	*Bulletin of the U.S. Bureau of Fisheries & Wildlife*
1	*Bureau of American Ethnology Bulletin*
4	*Canadian Journal of Botany*
1	*Canadian Journal of Fisheries and Aquatic Sciences*
1	*Canadian Journal of Forestry Research*
3	*Canadian Journal of Microbiology*
4	*Canadian Journal of Zoology*
41	*Cell*
22	*Cell & Tissue Research*
1	*Cell Motility and the Cytoskeleton*
1	*Chaski*
2	*Chemico Biological Interactions*
1	*Ciencia y Cultura*
1	*Ciencias Sociales*
3	*Cold Spring Harbor Symposia*
2	*Comparative Biochemistry & Physiology*
3	*Comparative Biochemistry and Physiology B*
1	*Comparative Biochemistry and Physiology C Comparative Pharmacology and Toxicology*
19	*Comprehensive Insect Physiology, Biochemistry & Pharmacology*
3	*Comptes Rendus de Seances Academy de Sciences Series D*
1	*Comptes Rendus Sommaire des Seances Societe Biogeographie*
1	*Condor*
1	*Conservation Biology*
1	*Contribution Gray Herbarium Harvard University*
1	*CRC Critical Reviews in Biochemistry*
4	*CRC Critical Reviews in Food Science*
6	*Crop Science*
1	*Cryptogamie Algologie*
2	*Current Anthropology*
1	*Current Topics in Developmental Biology*
1	*Current Topics in Microbiology*
1	*Cytobiologie*
1	*Cytochemistry*
1	*Cytologia*
2	*Deep Sea Biology*
47	*Deep Sea Research*
4	*Development*
3	*Developmental & Comparative Immunology*
22	*Developmental Biology*
4	*DNA*
4	*Ecological Monographs*
30	*Ecology*

1	*Physiological Reviews*
1	*Phytochemistry*
1	*Phytopathology*
1	*Plant Cell Physiology*
1	*Plant Physiology*
5	*Planta*
1	*Polish Archives of Hydrobiology*
1	*Polycyclic Hydrocarbons*
1	*Proceedings of the Biological Society of Washington*
5	*Proceedings of the National Academy of Science USA*
1	*Proceedings of the Royal Society of London Series B Biological Sciences*
1	*Progress in Phycological Research*
1	*Protoplasma*
1	*Pure and Applied Chemistry*
1	*Quarterly Review of Biology*
1	*Quaternary Research*
1	*Rapport et Proces Verbaux de Reurions Conseil International pour l'Exploration de la Mer*
2	*Reviews in Aquatic Sciences*
1	*Reviews of Environmental Contamination and Toxicology*
1	*Revue International d'Oceanographie Medicale*
8	*Science of the Total Environment*
1	*Scientific American*
1	*Search*
1	*Soap and Cosmetic Chemistry*
1	*Soil Biology and Biochemistry*
1	*Subcellular Biochemistry*
1	*Systematic & Applied Microbiology*
1	*Tetrahedron*
1	*Tetrahedron Letters*
3	*Thalassia*
3	*Theoretical Population Biology*
1	*Tin and its Uses*
1	*Tin International*
3	*Toxic Assessment*
3	*Toxicological and Environmental Chemistry*
5	*Toxicological Assessment an International Quarterly*
1	*Toxicologist*
5	*Toxicology and Applied Pharmacology*
1	*Toxicology and Industrial Health*
2	*Transaction of the British Mycological Society*
1	*Transactions of the American Fisheries Society*
1	*Transactions of the American Microscopical Society*
2	*Transactions of the Royal Microscopical Society*
1	*Travaux Museu d'Historie Grigore Antipa*
1	*Trends in Biochemical Science*
1	*Trudy Instituta Okeanologie Akademiya Nauk USSR*
2	*UC Davis Law Review*
1	*Vereoeffentlechungen des Instituts fuer Meeresforschung in Bremerhaven*
24	*Limnology & Oceanography*
1	*Lipids*
29	*Marine Biology*
1	*Marine Biology Letters*
3	*Marine Chemistry*
1	*Marine Ecology*
22	*Marine Ecology Progress Series*
20	*Marine Environmental Research*
4	*Marine Geology*
1	*Marine Micropaleontology*
29	*Marine Pollution Bulletin*
1	*Material and Organisms*
2	*Material und Organismen*
1	*Mathematical Biosciences*
1	*Memorie Accademie dei Lincei*
2	*Methods in Enzymology*
20	*Microbial Ecology*
2	*Microbiological Reviews*
1	*Microbiology*
1	*Micropaleontology*
1	*Molecular and Biochemical Parasitology*
3	*Molecular and Cellular Biology*
2	*Molecular Pharmacology*
7	*Mutation Research*
6	*Mycologia*
1	*National Fisherman*
22	*Nature*
3	*Netherlands Journal of Sea Research*
1	*Ocean and Shoreline Management*
2	*Ocean Development and International Law*
4	*Oceanography and Marine Biology*
7	*Oceanologica Acta*
1	*Oceanology*
5	*Oceans*
5	*Oceanus*
11	*Oecologia*
4	*Oikos*
1	*Okeanologiya*
2	*Ophelia*
1	*Oregon Law Review*
21	*Organic Geochemistry*
1	*Organometallic Chemistry*
1	*Organotin Compounds*
1	*Palaeogeography, Palaeoclimatology, Palaeoecology*
1	*Paleoceanography*
1	*Pesticide Biochemistry and Physiology*
4	*Pesticide Science*
1	*Pharmacology and Therapeutics*
1	*Philosophical Transactions of the Royal Society of London*
1	*Photochemistry*
1	*Phycology*

1	*Water, Air and Soil Pollution*
1	*Water Pollution Research*
1	*Water Pollution Research Journal of Canada*
4	*Water Research*
1	*Water Science and Technology*
1	*Yale Law Review*
1	*Yeast*
1	*Zeitschirft fur Naturoforschung*
1	*Zentralblatt fuer Bakteriologie Parasitenkunden*
1	*Zentralblatt fur Bakteriologie, Mikrobiologie und Hygiene*
18	*Economic Botany*
21	*EMBO Journal*
9	*Endeavour*
1	*Environmental Deep Sea*
1	*Environmental Health Perspectives*
4	*Environmental Science & Technology*
3	*Environmental Toxicology & Chemistry*
2	*Enzymes*
1	*Enzymologica*
2	*Eos*
4	*Estuarine, Coastal & Shelf Science*
1	*Estudios Arqueologicos*
1	*Etnia*
12	*European Journal of Biochemistry*
6	*European Journal of Cell Biology*
3	*European Survey of Marine Biology*
4	*European Symposia on Marine Biology*
45	*Evolution*
1	*Evolution Genetics*
1	*Evolution Theory*
12	*Experientia*
3	*Experimental Biology*
16	*Experimental Cell Research*
8	*Experimental Eye Research*
2	*FASEB Journal*
112	*FEBS Letters*
6	*Federation Proceedings*
1	*Flora Neotropica*
2	*Fortschrifte del Chemie Organischer Naturstoffe*
1	*Free Radicals Research Communications*
1	*Functional Ecology*
1	*Galathea*
7	*Gamete Research*
3	*Gene*
4	*Genes & Development*
2	*Genetics*
6	*Geochimica et Cosmochimica Acta*
1	*Geological Society of America Bulletin*
1	*Geomicrobiology Journal*
2	*Helgolander Wissenschaftlich Meeresuntersuchungen*
6	*Heredity*
1	*Histochemical Journal*
2	*Hoppe-Seyler's Zeitschrift fuer Physiologische Chemie*
1	*Humanitas*
5	*Hydrobiologia*
3	*Ibis*
1	*Indian Journal of Experimental Biology*
98	*Insect Biochemistry*
1	*International Botanical Congress Berlin*

1	*International Journal of Invertebrate Reproduction and Development*
1	*International Revue de Gesamten Hydrobiologie*
1	*Investigacion Arqueologica*
25	*Investigative Ophthalmology & Visual Science*
1	*Journal Bombay Natural History Society*
1	*Journal d'Agriculture Tropicale et de Botanique Appliquee*
1	*Journal de la Societe Centrale d'Horticulture du Nord*
1	*Journal de las Societe de Americanistes*
2	*Journal of Animal Ecology*
1	*Journal of Anthropology*
1	*Journal of Applied Ecology*
3	*Journal of Bacteriology*
1	*Journal of Biogeography*
151	*Journal of Biological Chemistry*
2	*Journal of Cell Biochemistry*
33	*Journal of Cell Biology*
4	*Journal of Cell Science*
1	*Journal of Cellular & Comparative Physiology*
4	*Journal of Cellular Biochemistry*
1	*Journal of Chromatography*
21	*Journal of Comparative Physiology*
12	*Journal of Comparative Physiology A Sensory & Neural & Behavioral Physiology*
2	*Journal of Crustacean Biology*
11	*Journal of Ecology*
1	*Journal of Economic Entomology*
15	*Journal of Experimental Biology*
8	*Journal of Experimental Marine Biology & Ecology*
1	*Journal of Experimental Zoology*
1	*Journal of Field Archeology*
3	*Journal of Field Ornithology*
7	*Journal of General Microbiology*
14	*Journal of General Physiology*
5	*Journal of Heredity*
26	*Journal of Insect Physiology*
8	*Journal of Investigative Dermatology*
1	*Journal of Liquid Chromatography*
1	*Journal of Magnetic Resonance*
1	*Journal of Mammalogy*
1	*Journal of Marine Biology*
1	*Journal of Marine Biology & Ecology*
5	*Journal of Marine Research*
1	*Journal of Marketing Research*
1	*Journal of Material Science*

3	*Journal of Medicinal Chemistry*
1	*Journal of Microbiology Methods*
2	*Journal of Microscopy*
1	*Journal of Molecular & Applied Genetics*
9	*Journal of Molecular Biology*
4	*Journal of Molecular Evolution*
10	*Journal of Molluscan Studies*
1	*Journal of Morphology*
1	*Journal of Muscle Research and Cell Motility*
9	*Journal of Neurocytology*
2	*Journal of Neurogenetics*
4	*Journal of Organic Chemistry*
5	*Journal of Paleontology*
1	*Journal of Phycology*
1	*Journal of Physical Chemistry*
2	*Journal of Plankton Research*
4	*Journal of Protozoology*
1	*Journal of Range Management*
4	*Journal of Reproduction & Fertility*
3	*Journal of Sedimentary Petrology*
3	*Journal of Submicroscopic Cytology & Pathology*
23	*Journal of the American Chemical Society*
1	*Journal of the Chemical Society*
7	*Journal of the Chemical Society Chemical Communications*
2	*Journal of the Chemical Society Faraday Transactions*
1	*Journal of the Fisheries Research Board of Canada*
1	*Journal of the Indian Institute of Science*
2	*Journal of the Linnean Society of Botany*
11	*Journal of the Marine Biological Association of the United Kingdom*
1	*Journal of the New York Botanical Garde*
1	*Journal of the Royal Horticultural Society*
1	*Journal of the Royal Statistical Society B*
1	*Journal of the Steward Anthropological Society*
3	*Journal of the Washington Academy of Science*
3	*Journal of Theoretical Biology*
2	*Journal of Tropical Ecology*
4	*Journal of Ultrastructure & Molecular Structure*
16	*Journal of Ultrastructure Research Supplement*
3	*Journal of Virology*
2	*Journal of Zoology*
9	*Kulturfplanze*
1	*Kurtziana*

1	*L'Homme*
1	*La Sierra*
1	*Latin American Research Review*
3	*Lethaia*
2	*Life Sciences*
21	*Limnology & Oceanography*
1	*Madrono*
6	*Maize Genetics Cooperation Newsletter*
15	*Malacologia*
4	*Malaysian Forester*
1	*Mammalian Genome*
22	*Marine Biology*
1	*Marine Chemistry*
1	*Marine Ecology*
40	*Marine Ecology Progress Series*
6	*Marine Environmental Research*
4	*Marine Geology*
1	*Marine Geology & Oceanography*
1	*Marine Microbial Food Webs*
4	*Marine Pollution Bulletin*
1	*Mathematical Geology*
1	*Mechanisms of Ageing and Development*
1	*Meddelser fra Kommissionen for Donmakr Fiskeri or Havundersigelser Serie Plankton*
4	*Medicinal Research Review*
2	*Memoirs of the Society of American Archeology*
1	*Memoirs of the University of Michigan Museum of Anthropology*
13	*Methods in Enzymology*
1	*Michigan Agricultural Experimental Station Bulletin*
7	*Microbial Ecology*
2	*Microbiological Reviews*
13	*Molecular & Cellular Biochemistry*
9	*Molecular & Cellular Biology*
3	*Molecular & General Genetics*
1	*Molecular Biology and Evolution*
3	*Molecular Entomology*
1	*Molecular Pharmacology*
1	*Molecular Reproduction & Development*
1	*Monatschrift des Vereins zur Beforderung des Gartenbaues*
86	*Nature*
2	*Naturwissenschaften*
1	*Nautilus*
2	*Nawpa Pacha*
1	*New England Journal of Medicine*
1	*New Phytology*
2	*New Zealand Journal of Botany*
31	*Nucleic Acids Research*
1	*Occasional Papers Idaho State University*

	Museum
3	*Oceanography & Marine Biology*
7	*Oceanologica Acta*
1	*Oceanology*
23	*Oecologia*
6	*Oikos*
3	*Okeanologija*
4	*Ophelia*
9	*Organic Prepararations and Procedures International*
1	*Ostrich*
1	*Oxford Review of Reproduction*
1	*Paleobiology*
3	*Parasitology Today*
1	*Peru Indigena*
1	*Philosophical Transaction of the Royal Society of London Series A Mathematical and Physical Science*
3	*Philosophical Transactions of the Royal Society of London Series B Biological Sciences*
1	*Photochemistry & Photobiology*
1	*Physiological Entomology*
3	*Physiological Reviews*
1	*Physiology Insecta*
2	*Phytochemistry*
2	*Phytomorphology*
1	*Plant & Soil*
3	*Plant Breeding*
2	*Plant Cell & Environment*
1	*Plant Genetics Research News*
11	*Plant Molecular Biology*
2	*Plant Physiology & Biochemistry*
2	*Plant Science*
1	*Plant Science Letters*
3	*Plant Systematics & Evolution*
3	*Principes*
1	*Proceedings Malacological Society of London*
25	*Proceedings of Royal Society of London Series B Biological Sciences*
1	*Proceedings of the Boston Society of Natural History*
37	*Proceedings of the National Academy of Science US*
1	*Proceedings of the Society for Experimental Biology & Medicine*
1	*Publicacion del Instituto Riva Aguero*
1	*Quarterly Journal of Microscopical*
7	*Science*
5	*Quarterly Review of Biology*
1	*Quaternary Research*

1	*Radiation Physics and Chemistry*
2	*Recent Advances in Embryology*
3	*Records Australian Museum*
1	*Relaciones de la Sociedad Argentina de Antropologia Nueva Serie*
2	*Relaciones de la Sociedad Argentina de Agronomia*
1	*Reviews in Aquatic Sciences*
2	*Reviews of Chemical Intermediates*
1	*Revista de Biologia Tropical*
10	*Revista de la Sociedad Argentina de Ciencias Naturales*
1	*Revista del Museo Nacional de Peru*
1	*Revista Espanola de Antropologia Americana*
1	*Revista Sociedad Argentina de Agronomia*
1	*Revista Trimestral de Estudios Antropologicos*
1	*Revista Universitaria Santiago*
1	*Revue de Cytologie et Biologie Vegetale*
4	*Runa*
93	*Sarsia*
1	*Science*
1	*Science of Horticulture*
8	*Scientific American*
1	*Sea*
2	*Selbyana*
1	*Silvae Genetica*
1	*Smithsonian Contributions in Zoology*
2	*Society of Neuroscience Abstracts*
1	*Southwestern Journal of Anthropology*
1	*Stain Technology*
2	*Symposia Society of Experimental Biology*
6	*Symposia Zoological Society of London*
3	*Synthesis Stuttgart*
1	*Systematic Association Publication*
3	*Systematic Association Special Publications*
6	*Systematic Botany*
2	*Systematic Zoology*
14	*Taxonomy*
1	*Tetrahedron*
1	*Texas A & M University Oceanographical Bulletin*
11	*Thalassia*
2	*Theoretical & Applied Genetics*
1	*Theoretical Population Biology*
2	*Thetys*
1	*Tissue & Cell*
1	*Toxicological & Environmental Chemistry*
1	*Transactions of the Royal Entomological Society of London*
	Travaux de L'Institute Francaise d'Estudes

4	*Andines*
3	*Trends in Biochemical Science*
2	*Trends in Ecology*
1	*Trends in Ecology & Evolutions*
1	*Trends in Genetics*
1	*Tropical Agriculture*
1	*Tropical Grain & Legume Bulletin*
18	*U.S. Biological Bulletin*
3	*UCLA Symposia in Molecular and Cellular Biology*
1	*Veliger*
2	*Verhandtungen des Botanischen Vereins fur die Provinz Brandenburg*
15	*Virology*
3	*Vision Research*
2	*Visual Neuroscience*
1	*Water, Air & Soil Pollution*
1	*Wayka*
2	*Wilson Bulletin*
1	*Wood Science and Technology*
1	*World Archeology*
11	*Zeitschrift fur Ethnologie*
1	*Zeitschrift fur Naturforschung C a Journal of Biosciences*
2	*Zeitschrift fur Naturoforschund*
1	*Zeitschrift fur Zelforschung und Miroskopische Anatomie*
6	*Zeitscrift fur Naturoforschung Section A Journal of Physical Science*
1	*Zoologica Scripta*
3	*Zoological Science*
	Zoologischesky Zhurnal

APPENDIX D

ISOMORPHISM OF THE HALF-LIFE DATA OF THE JOURNALS CITED BY THE UMB ENVIRONMENTAL SCIENCES AND BIOLOGISTS WITH THAT OF *JCR* BY SUBJECT CATEGORY

1988 TO 1992

Subject	Year	Environmental Scientists				Biologists			
		Isomorphic Half-Life		Non-Isomorphic Half-Life		Isomorphic Half-Life		Non-Isomorphic Half-Life	
		Number of Cases	Percentage	Number of Cases	Percentage	Number of Cases	Percentage	Number of Cases	Percentage
Biochemistry and Molecular Biology	1988			8	100	11	42	15	53
	1989	4	21	15	79	14	56	11	44
	1990	6	35	11	65	11	48	12	52
	1991					3	18	14	82
	1992	1	13	7	87	9	45	11	55
Biology	1988					4	80	1	20
	1989					6	100		
	1990								
	1991								
	1992					6	86	1	14
Botany	1988								
	1989								
	1990	7	64	4	36				
	1991								
	1992								
Chemistry	1988								
	1989								
	1990								
	1991	3	60	2	40				
	1992								
Chemistry, Inorganic and Nuclear	1988								
	1989	5	100						
	1990								
	1991								
	1992								
Chemistry, Organic	1988								

	1989					4	80	1	20
	1990								
	1991								
	1992								
Cytology and Histology	1988								
	1989					6	75	2	25
	1990	4	57	3	43	3	60	2	40
	1991								
	1992					5	62	3	38
Ecology	1988					9	100		
	1989					5	100		
	1990	6	100			12	92	1	8
	1991								
	1992	5	60	4	40	9	90	1	10
Entomology	1988					6	100		
	1989					5	100		
	1990					5	100		
	1991								
	1992								
Environmental Sciences	1988	6	60	4	40				
	1989	11	61	7	39	5	71	2	29
	1990	3	43	4	57				
	1991	5	56	4	44				
	1992	7	47	3	53				
Genetics & Heredity	1988								
	1989								
	1990					3	60	2	40
	1991								
	1992					4	57	3	49
Marine & Freshwater Biology	1988					4	80	1	20
	1989	5	100						
	1990	11	85	2	15	9	75	3	25
	1991	5	62	5	38				
	1992	9	82	2	18	7	64	3	36
Microbiology	1988	7	64	4	36				
	1989	5	100			7	87	1	13
	1990	6	55	5	45	4	80	1	20

	1991	3	60	2	40				
	1992	5	71	2	29				
Oceanography	1988	4	80	1	20				
	1989	4	80	1	20				
	1990	6	100						
	1991	8	100						
	1992	7	88	1	12	4	80	1	20
Ornithology	1988					5	100		
	1989								
	1990								
	1991								
	1992								
Plant Sciences	1988								
	1989								
	1990								
	1991								
	1992					2	25	6	75
Toxicology	1988								
	1989	4	80	1	20				
	1990								
	1991								
	1992								
Zoology	1988					3	43	4	57
	1989					3	60	2	40
	1990					2	33	4	67
	1991								
	1992					2	33	4	67

APPENDIX E

ISOMORPHISM OF THE RANKINGS OF THE JOURNALS CITED BY THE UMB ENVIRONMENTAL SCIENCES AND BIOLOGISTS WITH THAT OF *JCR* BY SUBJECT CATEGORY

1988 TO 1992

Subject Category	Year	ENVIRONMENTAL SCIENTISTS					BIOLOGISTS				
		Isomorphic Journal Rankings		Non-Isomorphic Journal Rankings		Hypothesis	Isomorphic Journal Rankings		Non-Isomorphic Journal Rankings		Hypothesis
		Number	Percentage	Number	Percentage		Number	Percentage	Number	Percentage	
Biochemistry and Molecular Biology	1988			8	100%	Not Supported	11	42%	15	53%	Not Supported
	1989	4	21%	15	79%	Not Supported	14	56	11	44%	Not Supported
	1990	6	35%	11	65%	Not Supported	11	48%	12	52%	Not Supported
	1991						3	18%	14	82%	Not Supported
	1992	1	13%	7	87%	Not supported	9	45%	11	55%	Supported
Biology	1988						4	80%	1	20%	Supported
	1989						6	100%			Supported
	1990										
	1991										
	1992						6	86%	1	14%	Supported
Botany	1988										
	1989										
	1990	7	64%	4	36%	Supported					
	1991										
	1992										
Chemistry	1988										
	1989										
	1990										
	1991	3	60%	2	40%	Supported					
	1992										
Chemistry, Inorganic and Nuclear	1988										
	1989	5	100%			Supported					

	1990										
	1991										
	1992										
Chemistry, Organic	1988										
	1989						4	80%	1	20%	Supported
	1990										
	1991										
	1992										
Cytology and Histology	1988										
	1989						6	75%	2	25%	Supported
	1990	4	57%	3	43%	Supported	3	60%	2	40%	Supported
	1991										
	1992						5	62%	3	38%	Supported
Ecology	1988						9	100%			Supported
	1989						5	100%			Supported
	1990	6	100%			Supported	12	92%	1	8%	Supported
	1991										
	1992	5	100%?	4	80%?	Supported	9	90%	1	10%	Supported
Entomology	1988						6	100%			Supported
	1989						5	100%			Supported
	1990						5	100%			Supported
	1991										
	1992										
Environmental Sciences	1988	6	60%	4	40%	Supported					
	1989	11	61%	7	39%	Supported	5	71%	2	29%	Supported
	1990	3	43%	4	57%	Not Supported					
	1991	5	56%	4	44%	Not Supported					
	1992	7	47%	3	53%	Not Supported					
Genetics and Heredity	1988										
	1989										
	1990						3	60%	2	40%	Supported
	1991										
	1992						4	57%	3	49%	Not Supported
Marine and Freshwater Biology	1988						4	80%	1	20%	Supported
	1989	5	100%			Supported					

	1990										
	1991										
	1992										
Chemistry, Organic	1988										
	1989						4	80%	1	20%	Supported
	1990										
	1991										
	1992										
Cytology and Histology	1988										
	1989						6	75%	2	25%	Supported
	1990	4	57%	3	43%	Supported	3	60%	2	40%	Supported
	1991										
	1992						5	62%	3	38%	Supported
Ecology	1988						9	100%			Supported
	1989						5	100%			Supported
	1990	6	100%			Supported	12	92%	1	8%	Supported
	1991										
	1992	5	100%?	4	80%?	Supported	9	90%	1	10%	Supported
Entomology	1988						6	100%			Supported
	1989						5	100%			Supported
	1990						5	100%			Supported
	1991										
	1992										
Environmental Sciences	1988	6	60%	4	40%	Supported					
	1989	11	61%	7	39%	Supported	5	71%	2	29%	Supported
	1990	3	43%	4	57%	Not Supported					
	1991	5	56%	4	44%	Not Supported					
	1992	7	47%	3	53%	Not Supported					
Genetics and Heredity	1988										
	1989										
	1990						3	60%	2	40%	Supported
	1991										
	1992						4	57%	3	49%	Not Supported
Marine and Freshwater Biology	1988						4	80%	1	20%	Supported
	1989	5	100%			Supported					

APPENDIX F

STATISTICAL CORRELATION OF THE RANKINGS OF THE JOURNALS CITED BY THE UMB ENVIRONMENTAL SCIENCES AND BIOLOGISTS WITH *JCR* JOURNAL RANKINGS WITH SPEARMAN'S RHO BY SUBJECT CATEGORY

1988 TO 1992

Subject	Year	Environmental Scientists				Biologists			
		Number of Journal Rankings	Spearman's Rho Value Found	Statistically Significant Correlation Value at the 0.05 Level	Statistical Correlation Found	Number of Journal Rankings	Spearman's Rho Value Found	Statistically Significant Correlation Value at the 0.05 Level	Statistical Correlation Found
Biochemistry and Molecular Biology	1988	10	0.031	0.564	No Correlation	26	0.229	0.329	Moderate
	1989	19	0.127	0.377	Low Correlation	25	0.013	0.343	No Correlation
	1990	17	0.010	0.399	No Correlation	23	0.483	0.359	High
	1991					18	0.218	0.319	Moderate
	1992	8	0.577	0.643	Moderate	20	0.080	0.377	No Correlation
Biology	1988					5	0.783	0.900	Moderate
	1989								
	1990					8	0.814	0.643	High
	1991								
	1992					7	0.019	0.714	No Correlation
Botany	1988								
	1989								
	1990	11	0.000	0.506	No Correlation	16	0.028	0.425	No Correlation
	1991								
	1992								
Chemistry	1988								
	1989								
	1990								
	1991	5	0.335	0.900	Low Correlation				
	1992								
Chemistry, Inorganic and Nuclear	1988	5	0.707	0.900	Moderate				

	1989								
	1990								
	1991								
	1992								
Chemistry, Organic	1988								
	1989					5	0.872	0.900	Moderate
	1990								
	1991								
	1992								
Cytology and Histology	1988								
	1989					8	0.098	0.900	No Correlation
	1990	7	0.143	0.714	Low Correlation	5	0.462	0.900	Moderate
	1991								
	1992					8	0.196	0.643	Low Correlation
Ecology	1988					9	0.186	0.600	Low Correlation
	1989					5	0.112	0.900	No Correlation
	1990	6	0.143	0.829	No Correlation	13	0.637	0.506	Moderate
	1991								
	1992	5	0.211	0.900	No Correlation	11	0.708	0.506	High
Entomology	1988					6	0.257	0.829	Low Correlation
	1989					6	0.143	0.829	No Correlation
	1990					5	0.000	0.900	No Correlation
	1991								
	1992								
Environmental Sciences	1988	10	0.137	0.564	Low Correlation				
	1989	18	0.062	0.399	No Correlation	7	0.055	0.714	No Correlation
	1990	10	0.448	0.564	Moderate				
	1991	8	0.525	0.643	Moderate				
	1992	7	0.407	0.714	Moderate				
Genetics and Heredity	1988								
	1989								
	1990					5	0.000	0.900	No Correlation

	1991								
	1992					7	0.668	0.714	Moderate
Marine and Fresh Water Biology	1988					5	0.975	0.900	High
	1989	7	0.251	0.714	Low Correlation				
	1990	13	0.308	0.456	Moderate	12	0.149	0.506	Low Correlation
	1991	13	0.360	0.456	Moderate				
	1992	11	0.465	0.564	Moderate	11	0.290	0.506	Moderate
Microbiology	1988	11	0.229	0.506	Moderate				
	1989	13	0.119	0.456	Low Correlation	8	0.166	0.643	Low Correlation
	1990	11	0.448	0.506	Moderate	5	0.335	0.900	Low Correlation
	1991	5	0.262	0.900	Low Correlation				
	1992	7	0.265	0.714	Moderate				
Oceanography	1988	5	0.707	0.900	Moderate				
	1989	5	0.949	0.900	High				
	1990	6	0.551	0.829	Moderate				
	1991	8	0.136	0.643	Low Correlation				
	1992	8	0.822	0.643	High	5	0.975	0.900	High
Ornithology	1988					5	0.154	0.900	No Correlation
	1989								
	1990								
	1991								
	1992								
Plant Sciences	1988								
	1989								
	1990								
	1991								
	1992					8	0.080	0.829	No Correlation
Toxicology	1988								
	1989	5	0.477	0.900	Moderate				
	1990								
	1991								
	1992								
Zoology	1988					5	0.000	0.714	No Correlation

1989			5	0.000	0.900	No Correlation
1990			6	0.200	0.829	Low Correlation
1991						
1992						

APPENDIX G

UMB ACQUISITIONS POLICY STATEMENT

UMB ACQUISITIONS POLICY STATEMENT

The most important part of acquisitions work takes place before the publications are actually ordered. This work involves the planned selection of materials best suited to meet the University's needs for instruction, research, and cultural preservation. The importance of wise selection has increased greatly in recent years due to the rapidly rising costs of materials and the none too rapid rise in the funds needed to purchase these materials. The responsibility for selection lies with the faculty and the Library staff. The faculty is largely responsible for recommending the acquisition of publications in their special fields. The Library staff must take the responsibility for the fields neglected by the faculty, for coordinating the development of the collection as a whole, and for assisting the faculty in the selection process. In the achievement of these goals, a general policy for acquisitions must play an important role.

Since a library is not a fixed thing, an acquisitions policy statement cannot be definitive for all time. Our ideas about the nature and contents of a university library are constantly evolving to reflect the changes of the university itself. Thus a policy statement needs to be practical and responsive to change. It will be the duty of the Library staff and the University Library Committee to periodically review this document to ensure that it is reflective of such changes.

Obligations

The University should plan to acquire, as far as is financially practicable, library materials to meet these four obligations:

1. To procure and make available those library materials needed for the instructional programs of the university.

2. To procure and make available those library materials required by students and faculty in their research.

3. To procure and make available those library materials of general information in subject areas not covered by instructional or research programs.

4. To preserve all important materials relating to the history and development of UMass/Boston.

Limitations

It will seldom be possible, for financial reasons, to adequately meet all of the previously mentioned obligations. Therefore, the Library will observe the following general guidelines:

1. When acquisitions are limited due to lack of funds, current publications of lasting and scholarly value will be given priority over older and out-of-print materials.

2. English language publications will be given higher priority.

3. Area library resources will be taken into consideration in relation to the proposed purchase of infrequently used research materials.

4. Materials will be acquired in another suitable format if originals are not available, are too expensive, or present storage or preservation problems.

5. If the Library holds material in microform, hard copy will not

be purchased unless sufficient cause is shown.

6. Duplicate copies will be purchased only by justification of heavy and continued use.

7. Specialized research materials will not be duplicated unless dicated by special circumstances.

8. Variant editions of a title held will be acquired only if they are "standard" editions or contain substantial changes needed for research purposes. This does not apply to updated editions of scientific or technical publications.

9. The Library will not purchase extensive in-depth materials for specific research projects unless the Library's acquisitions policy specifies an intensive collection development level in that area.

10. The Library will make no special effort to collect materials in non-western languages, even in subject areas of comprehensive coverage, if there is no sizable number of researchers on campus with facility in that language.

Duplication

Since present Library funds do not permit the purchase of all materials needed for teaching and research, the purchase of duplicate copies of books and serials will be acquired only in accordance with the following guidelines:

1. Multiple demand and heavy, continuous use of individual titles will be the primary consideration for the purchase of duplicate titles.

2. No duplicate publications will be acquired solely for the sake

of preservation except for selected materials maintained for archival purposes.

3. Duplicate publications received as gifts or on exchange will be subject to the same consideration for addition as materials suggested for purchase.

4. Past policies and historical circumstances will not be considered as a justification for new and continued duplication.

5. The Library will not purchase duplicate copies, or publications not held by the Library, for the sole use of individuals, academic departments, or administrative offices.

6. The cost of any given publication, together with the financial situation of the Library, may be the overriding factor in applying these guidelines.

Gifts

1. The Library solicits and encourages gifts and donations of useful materials, or money to purchase them, provided they fit into existing acquisitions policies and provided there are no restrictions attached.

2. The Library will not accept gifts with conditions as to their disposition or location except by the express permission of the Director of Libraries.

3. The Library is free to dispose of any unneeded publications regardless of how they were acquired.

4. The Library cannot legally appraise gifts for tax or

inheritance purposes. The Library may, however, assist the donor in obtaining, if available, prices listed in auction records or in catalogs of secondhand booksellers. If a substantial collection is involved, the Library may help the donor to procure a professional appraisal.

5. The responsibility for accepting gifts to the Library rests with the Head of Acquisitions.

Levels of Collection Intensity

It is recognized that the requirements for library materials vary in different subject areas. In many scientific and technical fields the primary needs are met by serials whereas books are of main importance in the social sciences and humanities. Current and projected degree and research programs have been used to indicate the degrees of acquisition intensity which the Library will attempt to follow in meeting the needs of the academic departments. The level of intensity of acquisition effort are as follows:

1. General Level

A highly selective collection serving to introduce and define a subject not necessarily represented in the university curricula. It shall include some textbooks, dictionaries, encyclopedias, selected editions of important works of major authors, historical surveys, biographies, fundamental bibliographies, and several periodicals for keeping in touch with current scholarship in the field. The level of coverage would include primarily English language materials.

2. Undergraduate Level

A good working collection designed to meet all the instructional needs at the undergraduate level. It shall include a wide range of basic works, complete collections of the works of important figures, both authors and critics, selections from the works of secondary writers, yearbooks, handbooks, a wide range of representative journals, and the fundamental reference works and bibliographies.

3. Instructional/Research Level

A collection of materials in English and other languages covering fundamental works of scholarship for use of upper level undergraduate students, graduate students, and faculty. In addition to current materials, the Library will attempt to obtain retrospective works including serials, reference sets, and bibliographies.
This level is intended to serve areas granting baccalaureate and masters degrees.

4. Comprehensive Research Level

A comprehensive collection of materials for independent study by graduate students and faculty. It shall include all the important or useful works, both current and retrospective, and extensive assemblage of critical and bibliographical works, complete sets of serials, documents, and other pertinent materials. This collection level is intended to serve areas offering the Ph.D. degree or anticipating to do so in the near future.

5. Exhaustive Research Level

This collection shall include, as far as possible, all publications

of research value, including marginal materials such as manuscripts, archives, and ephemera. Such a collecting level will be undertaken only in restricted areas, such as materials by or about a single literary or historical figure.

The use of any number listed above implies that responsibility will be assumed by the Library for that level of coverage in the subject areas that follow.

Subject	Level	Librarian
Accounting	3	SH
Taxation		
Public accounting		
Business accounting		
African Languages & Literature	1-2	MM
Agriculture	1	SH
American Language & Literature		
Language & Grammar	2	JO
Colonial & Early Republic	3	JO
19th Century	3	DG
20th Century	3	DG/JO
Anthropology	2-3	PS
Physical anthropology		
Ethnology		
Prehistoric archaeology		
Folklore	2	PS
Aquaculture	2	BC
Archives	3	EM
Astronomy	2	DR
Biology	3	DR
Botany		
Zoology		
Physiology		
Microbiology		
Ecology		
Black Studies	2-3	PP
Buddhism	1-2	JD
Celtic Language & Literature		DG
Irish	2	
Other	1	
Chemistry	3	DR
Analytical		
Inorganic		
Organic		
Physical		
Children's Literature	1-2	BC
Chinese Language & Literature	2	LT
Christianity	2	EM
Classical Language & Literature		GG
Greek	3	
Latin		
Classical	3	
Medieval	2	
Costume & Fashion	2	DG
Dance	1-2	AC
Economics	3	GG

Economic Theory		SH
Demography		
Economic history		
Education	2-3	DG
History of education		
Theory and practice		
Teaching		
Educational psychology		
Preschool		
Primary		
Elementary		
Secondary		
Teacher education		
Higher education		
School administration		
Engineering	1-2	DG
English Languge & Literature		
Language & Grammar	2	JO
Old English	2	MM
Middle English	2	MM
English Renaissance	3	MM
17th Century	3	MM
18th Century	3	MM
19th Century	3	MM
20th Century	3	JD
Environmental Science	4	DR
Etiquette & Social Usages	1-2	DG
Film		DG
History	2	
Theory & Criticism	1	
Production	2	
Finance	3	SH
Money		
Banking		
Credit		
Stocks		
Insurance		
Real Estate		
Fine Arts	2-3	AC
History of art		
Technique		
Art criticism		
Architecture		
Sculpture		
Drawing		
Painting		
Print media		
Decorative arts		
Photography		
Forestry	1	JO
Genealogy	1	EM
Geography	2	FS
United States	3	EM
Colonial		
Revolution		
Pre-Civil War		
Civil War		
Post-Civil War		
Twentieth Century		
New England		
Massachusetts	4	
Boston	4	
Mexico	2-3	GG
Central America	2-3	JS
West Indies	2-3	JS
South America	2-3	GG
Horticulture	1	JO
Hotel & Restaurant Management	1	SH
Indo-Iranian Languges & Literatures		EM
Armenian	2	
Others	1	
Islam	1	JD
Japanese Language & Literature	2	LT
Judaism	2	GG
Law	3	FS/PP
Federal law		
State law		
International law		
Library Science	2	JO
Libraries & Collections		
Library organization & systems		
Library automation		
History of the Book/Publishing		
Bibliography		
Linguistics	3	GG
Mass Communications	2	DG
Radio	1	
Television	2	
Theory & History	2	
Journalism	2	
Management	3	SH
Public administration		
Business administration		
Personnel		
Marketing	3	SH
Sales		
Advertising		
Mathematics	3	DR
Computer Science	4	DR
Elementary mathematics		
Algebra		
Geometry		
Mathematical analysis		

Cartography		
Hydrology		
Oceanography		
Human ecology		
Maps	2	DR
Geology		
Mineralogy		
Petrology		
Paleontology		
German Language & Literature	2-3	GG
	2-3	PP
Gerontology	3	
History	2	EM
Ancient history	2	DG
Medieval history	2	EM
Modern history		
World War I		
World War II		
Great Britain	3	EM
England		
Wales		
Scotland		
Ireland	2	JO
Austria	2-3	GG
Balkan Peninsula	2	GG
Baltic states	1	GG
Czechoslovakia	2	GG
France	3	GG
Germany	3	GG
Greece	1-2	GG
Hungary	1-2	GG
Italy	3	GG
Low countries	2-3	GG
Russia	3	GG
Poland	2	GG
Northern Europe	1	GG
Roumania	1-2	GG
Scandinavia	2	GG
Spain	2	GG
Portugal	1-2	GG
Turkey	2	PA
Middle East	2	PA
China	2-3	LT
India & Himalayan countries	2-3	PS
Japan	2-3	LT
Asia	2	LT
Africa	2-3	PA
Oceania	2	PS
North America	3	JS
Canada	2	JS
British America	3	JS
Indians of North America	2	DG

		DG/DR
Medicine		
History of medicine	1	
Public health	2	
Hospital administration	3	
Internal medicine	1	
Geriatrics	2	
Neurology	1	
Psychiatry	2	
Surgery	2	
Pediatrics	1	
Pharmacy	2	
Nursing	3	
Military & Naval Sciences	1	GG
Music	2-3	AC
Instrumental music	3	
Orchestral music	3	
Vocal music	2	
Sacred vocal music	2	
Literature of music	2	
History and criticism	2	
Composition	2	
Instrumental techics	2	
Singing	2	
Opera	2	
Musical Theatre	2	DG
Jazz	1	DG
Numismatics	1	GG
Occult Sciences	1	JO
Parapsychology	1	GG
Philosophy	2-3	AS
Logic		
Speculative philosophy		
Metaphysics		
Epistemology		
Ontology		
Cosmology		
Aesthetics		
Ethics		
Physics	3	DR
Political Science	3	FS/JS/PP
Political theory		
Constitutional history		
Government, national		
Government, local		
Political parties		
International relations		

	2-3	LT
Psychology		
Psychoanalysis		
Experimental	3	
Cognition	3	
Applied		
Developmental	2-3	PS
Recreation	1	
Outdoor life	2	
Physical training	3	
Sports medicine	2	
Sports	2	
Games & amusements	1	
Circuses	2	JD
Religion (general)	1	DG
Rhetoric & Oratory		
Romance Languages & Literature	2-3	PS
Italian	2-3	FS
French	2-3	GG
Spanish	2	GG
Portuguese	2	MM
Scandinavian Languages & Literatures	2	JO
Science Fiction/Mysteries	2	DR
Science, History of		GG
Slavic Languages & Literatures	2-3	
Russian	1	
Others	3	PP
Sociology		
Urban sociology		
Rural sociology		
Regional planning		
Social problems		
Criminology		EM
Welfare		EM
Charities		
Family		
Sex		
Penology		
Race relations	2	DR
Statistics	1	DG
Technology, History of	2	DG
Theatrical Arts	2	
Forms of Drama	2	
Playwriting	2	
Stagecraft & Design	2	
Dramatic Theory & Criticism	2	
Directing & Acting	2	
Theatre History	2	
Arts Management	1	
Children's Theatre	1-2	DR
Veterinary Medicine	2-3	MM
Women's Studies		

NON-BOOK MATERIAL

The Library will acquire the following forms of non-book materials as needed to meet the instructional needs of the University: phonograph records, audio cassettes and tapes, multi-media kits, slides, photographs, art reproductions, and maps. Until such time that the Library owns the equipment necessary for their utilization, computer software and video cassettes will not be purchased for addition to the general collection.

GOVERNMENT DOCUMENTS

(This section of the policy will be added at a later time)

MICROFORMS

Microforms (microcards, microfilm, microfiche, microprint) will be purchased in preference to printed copy, when available, in all cases involving bulky, expensive, and infrequently used research type material. The Library will purchase, on a selective basis, large microform projects of relevance to research or instructional programs within the framework of this acquisitions policy. When such microform series are purchased, the Library will attempt to avoid the purchase of printed copies of works found in the series unless there are exceptional circumstances related to such a purchase. Microform editions of single monographic titles will be purchased only if printed editions are not

available or very costly. Newspapers will be permanently retained in microform only.

SERIALS

Serials acquisitions requires a higher degree of selectivity than monographs because of the ongoing commitment involved in relation to terms of payment, binding, and storage. There is also a problem in the large number of publications available, for it is fiscally impossible to purchase all the titles needed.

In general principle, the Library will attempt to acquire:

1. Complete holdings of the leading serials in all major subject fields related to the instructional programs of the University;
2. Serials containing the results of professional scholarship;
3. Serials devoted to the informed discussion of public affairs;
4. Serials containing serious literature and criticism;
5. Serials presenting substantial factual information concerning economics, political and social events, and scientific knowledge;
6. Selected American popular periodicals of research value;
7. Back files of serials in original format or microform, depending on research needs, frequency of use, and availability of funds.

If a large number of titles is requested, the department involved will be asked to assign priorities in order of importance. This will be particularly observed if the request involves extensive and expensive

backfiles. As a general rule, backfiles will be purchased in microform when available. The decision to replace hard copy with microform will be made on an individual basis, but frequency of use will be an important consideration in such a decision. The Library will, in general, receive only one copy of any given serial publication. Decisions on duplication will be made on a title by title basis, with the main reason for duplication being frequency of use.

APPENDIX H

HEALEY LIBRARY STATISTICS FY 1993

UMASS/BOSTON
HEALEY LIBRARY

STATISTICS FY 93

Part I - Library Collection

	Total Added FY 93	Total Withdrawn	Total Hel
Printed Materials			
1. Serials, bound:	3,824	-0-	108,932
2. Monographs:	8,205	2,234	421,050
3. Scores:	15	-0-	5,809
4. Total (1-3):	12,044	2,234	535,791
5. Maps:	21	-0-	377
6. Media kits:	113	-0-	2,812
7. Total (5-6):	134	-0-	3,189
8. Current serial subscriptions:	4	230	3,104
9. Manuscripts & Archives: (in cubic feet)	44	-0-	2,012
Microforms			
10. Microfilm (reels):	392	-0-	29,651
11. Microcards:	0	-0-	42,932
12. Microfiche:	16,607	-0-	613,786
13. Total (10-12):	16,999	-0-	686,369
Catalogued non-print			
14. Audio	64	-0-	1,939
Uncatalogued Materials			
15. Computer software	5	-0-	82
16. Totals (4,7,13,14,15)	28,946	2,464	1,227,370

Part II - Library Services

17. Net assignable square footage	NA
18. Hours open	
Per typical week:	81
Days per typical week:	7
19. Circulation	
a. General collection:	103,415
b. Reserve collection:	51,038
c. Total circulation:	154,453
20. Attendance in Library	
a. Per typical week:	NA
b. Yearly total:	NA
21. Interlibrary Loan	
Items Lent:	
a. Originals:	1,332
b. Photocopies:	1,433
c. Total (a-b):	2,765
Items Borrowed:	
d. Originals:	1,270
e. Photocopies:	2,146
f. Total (d-e):	3,416
22. Reference	
a. Total reference transactions for year:	19,131
b. Total directional transactions for year:	11,592
23. Online Database Searching	
a. Searches for faculty:	7
b. Searches for students:	15
c. Other searches:	5
d. Total searches (a-c):	27
24. Staffing	
a. FTE librarians/ professional:	21
b. FTE classified:	20
c. FTE student hourly employees:	11
d. Total FTE staff (a-c):	52

*Estimate

Part III - Library Budget

25. Salaries	
a. Librarians/Professional:	848,912
b. Classified:	503,869
c. Student assistants (hourly):	39,928
e. Total salaries (a-c):	1,392,709
26. Equipment:	56,255
27. Supplies & Expenses	
a. External vendors:	19,896
b. College supply:	5,175
c. Duplicating:	542
d. Copy services:	9,108
e. Equipment service/repair:	6,984
f. Total (a-e):	41,705
28. Memberships	
a. Boston Athenaeum:	125
b. Boston Library Consortium:	20,000
c. Fenway Library Consortium:	275
d. Nelinet:	500
e. MCCLPHEI:	150
f. New England Library Association	35
g. New England Online Users Group (NENON):	90
h. Total (a-g):	21,175
29. Travel:	10,338
30. OCLC/Nelinet:	20,000
31. Materials	
a. Serials	
(1) Periodicals:	782,294
(2) SSO's:	87,934
Total (1-2):	870,228
b. CD-ROMs:	20,365
c. Books	
(1) Monographs:	246,157
(2) Continuations:	15,850
(3) Blanket orders:	5,079
Total (1-3):	267,086
d. A/V:	NA
e. Binding:	35,475
f. Microforms: *not included with SSO expenditures*	0
g. Computer software/licenses/upgrades:	5,443
h. Total for library materials (a-g):	1,198,597
32. Communications	
a. Telephones:	27,119
b. Postage:	6,641
c. Total (a-b):	33,760
33. SC-10:	13,866
34. Other budget items (specify):	
35. Total library budget:	2,788,405

Appendix I

Current Subscriptions at HL for the UMB Environmental Sciences Program

Title	Current Expenditure
ANALYST	641.00
ANALYTICA CHIMICA ACTA	3,269.00
ANALYTICAL BIOCHEMISTRY	1,370.00
ANTONIE VAN LEEUWENHOEK JOURNAL OF MICROBIOLOGY AND SEROLOGY	529.68
APPLIED MICROBIOLOGY AND BIOTECHNOLOGY	1,674.00
AQUATIC TOXICOLOGY	723.00
ARCHIVES OF ENVIRONMENTAL CONTAMINATION AND TOXICOLOGY	479.00
ARCHIVES OF MICROBIOLOGY	1,924.00
ATMOSPHERIC ENVIRONMENT	N/A
BIOCHEMISTRY JOURNAL	1,495.00
BIOCHEMICAL SOCIETY, TRANSACTIONS	225.00
BIOGEOCHEMISTRY	539.58
BIOLOGICAL TRACE ELEMENTS RESEARCH	405.00
BIOORGANIC CHEMISTRY	191.00
BIOTECHNOLOGY AND APPLIED BIOCHEMISTRY	175.00
BOTANICA MARINA	819.15
BOUNDARY LAYER METEOROLOGY	1,114.58
BULLETIN OF ENVIRONMENTAL CONTAMINATION AND TOXICOLOGY	379.00
BULLETIN OF MARINE SCIENCE	175.00
CHEMOSPHERE	1,495.00
COASTAL MANAGEMENT	152.00
COSTAL ZONE MANAGEMENT	355.00
COMMERCIAL FISHERIES NEWS	18.00
COMPUTERS AND FLUIDS	985.00
CONTINENTAL SHELF RESEARCH	760.00
DRUG METABOLISM AND DISPOSITION	140.00
DRUG METABOLISM REVIEWS	825.00
DYNAMICS OF ATMOSPHERE AND OCEANS	461.00
EARTH AND PLANETARY SCIENCE LETTERS	1,366.00
ECOLOGY LAW QUARTERLY	48.00
ECOTOXICOLOGY AND ENVIRONMENTAL SAFETY	351.00
ENVIRONMENT	66.00
ENVIRONMENTAL ACTION	40.00

ENVIRONMENTAL ETHICS	40.00
ENVIRONMENTAL FORUM	50.00
ENVIRONMENTAL HEALTH PERSPECTIVES	39.00
ENVIRONMENTAL HISTORY REVIEW	30.00
ENVIRONMENTAL POLICY AND LAW	248.00
ENVIRONMENTAL POLLUTION	1,250.00
ENVIRONMENTAL RESEARCH	714.00
ENVIRONMENTAL SCIENCE AND TECHNOLOGY	497.00
ENVIRONMENTAL SOFTWARE	330.00
ENVIRONMENTAL TOXICOLOGY AND CHEMISTRY	515.00
ENVIRONMENTAL TOXICOLOGY AND WATER QUALITY	195.00
EPA JOURNAL	7.50
ESTUARINE COASTAL AND SHELF SCIENCE	560.00
EUROPEAN JOURNAL OF BIOCHEMISTRY	2,150.00
GEOCHEMICAL JOURNAL	198.00
GEOCHIMICA ET COSMOCHIMICA ACTA	895.00
GLOBAL GEOCHEMICAL CYCLES	185.00
HAZARDOUS WASTE AND HAZARDOUS MATERIALS	162.00
HYDROBIOLOGIA	4,168.64
INDIAN ACADEMY OF SCIENCES. PROCEEDINGS EARTH AND PLANETARY SCIENCES	75.00
INTERNATIONAL JOURNAL OF ENVIRONMENTAL ANALYTICAL CHEMISTRY	3,144.00
INTERNATIONALE REVUE DER GESAMTEN HYDROBIOLOGIE	445.00
JOURNAL OF APPLIED BACTERIOLOGY	558.00
JOURNAL OF ATMOSPHERIC CHEMISTRY	368.74
JOURNAL OF CHEMICAL TECHNOLOGY AND BIOTECHNOLOGY	595.00
JOURNAL OF CHROMATOGRAPHIC SCIENCE	190.00
JOURNAL OF ENVIRONMENTAL EDUCATION	63.00
JOURNAL OF ENVIRONMENTAL MANAGEMENT	475.00
JOURNAL OF FISH DISEASES	437.00
JOURNAL OF FLUID MECHANICS	1,197.00
JOURNAL OF GENERAL AND APPLIED MICROBIOLOGY	114.85
JOURNAL OF HIGH RESOLUTION CHROMATOGRAPHY	379.20
JOURNAL OF INDUSTRIAL MICROBIOLOGY	725.42
JOURNAL OF INVERTEBRATE PATHOLOGY	392.00
JOURNAL OF LIPID RESEARCH	262.00

JOURNAL OF LIQUID CHROMATOGRAPHY	1,350.00
JOURNAL OF MARINE RESEARCH	90.00
JOURNAL OF MARITIME LAW AND COMMERCIAL	105.00
JOURNAL OF PHOTOCHEMISTRY AND PHOTOBIOLOGY B: BIOLOGY	1241.00
JOURNAL OF PHYSICAL OCEANOGRAPHY	235.00
JOURNAL OF PLANKTON RESEARCH	340.00
JOURNAL OF THE ATMOSPHERIC SCIENCES	350.00
JOURNAL OF THE IES	30.00
JOURNAL OF TOXICOLOGY AND ENVIRONMENTAL HEALTH	750.00
LIMNOLOGY AND OCEANOGRAPHY	160.00
MARINE AFFAIRS BIBLIOGRAPHY	95.00
MARINE BIOLOGY	2,426.00
MARINE CHEMISTRY	867.00
MARINE ECOLOGY PROGRESS SERIES	2,639.75
MARINE ENVIRONMENTAL RESEARCH	555.00
MARINE FISH MANAGEMENT	87.50
MARINE GEOLOGY	1,385.00
MARINE GEOPHYSICAL RESEARCHES	385.41
MARINE MAMMAL NEWS	67.50
MARINE POLICY	371.97
MARINE POLLUTION BULLETIN	430.00
MARINE RESOURCE ECONOMICS	100.00
MARITIME POLICY AND MANAGEMENT	307.00
MASS SPECTROMETRY REVIEWS	350.00
MICROBIAL ECOLOGY	254.00
MICROBIOLOGY	1,150.00
MICROCHEMICAL JOURNAL	306.00
MOLECULAR MICROBIOLOGY	1,090.00
NATIONAL FISHERMAN	22.95
NATIONAL RESOURCES AND ENVIRONMENT	23.00
NATIONAL RESOURCES JOURNAL	32.00
NAVAL WAR COLLEGE REVIEW	N/A
OCEAN AND COASTAL MANAGEMENT	565.00
OCEAN DEVELOPMENT AND INTERNATIONAL LAW	194.00
OCEAN SCIENCE NEWS	375.00
OCEANOLOGY	490.00

OPHELIA	196.72
ORGANIC GEOCHEMISTRY	700.00
PROGRESS IN OCEANOGRAPHY	705.00
RESOURCE AND ENERGY ECONOMICS	271.00
SCIENCE OF THE TOTAL ENVIRONMENT	2,387.00
SEA FRONTIERS	24.00
TOXICOLOGICAL AND ENVIRONMENTAL CHEMISTRY	3,148.00
TOXICOLOGY AND APPLIED PHARMACOLOGY	852.00
WATER ENVIRONMENT AND TECHNOLOGY	198.00
WATER RESEARCH	1,615.00
WATER RESOURCES RESEARCH	660.00
WATER AIR AND SOIL POLLUTION	1,516.65
XENOBIOTICA	821.00

Appendix J

Current Subscriptions at HL for the UMB Biologist

Title	Current Expenditure
AMERICAN BIOLOGY TEACHER	50.00
AMERICAN BIRDS	35.00
AMERICAN FISHERIES SOCIETY	400.00
AMERICAN JOURNAL OF BOTANY	155.00
AMERICAN JOURNAL OF PHYSIOLOGY	1,277.00
AMERICAN JOURNAL OF PRIMATOLOGY	894.00
AMERICAN MIDLAND NATURALIST	75.00
AMERICAN NATURALIST	180.00
AMERICAN ZOOLOGIST	400.00
ANNALS OF BOTANY	465.00
APPLIED AND ENVIRONMENTAL MICROBIOLOGY	265.00
ARCHIVES OF BIOCHEMISTRY AND BIOPHYSICS	1,392.00
ARNOLDIA	20.00
AUDUBON MAGAZINE	20.00
AUK	70.00
AUSTRALIAN JOURNAL OF BOTANY	195.00
BEHAVIORAL AND BRAIN SCIENCES	210.00
BEHAVIORAL ECOLOGY	147.00
BEHAVIORAL ECOLOGY AND SOCIOBIOLOGY	1,066.00
BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS	1,152.00
BIOCHEMISTRY	1,328.00
BIOCHEMISTRY AND CELL BIOLOGY	237.00
BIOCHIMICA ET BIOPHYSICA ACTA	7,322.00
BIODEGRADATION	230.20
BIOLOGIA PLANTARUM	249.47
BIOLOGICAL BULLETIN	180.00
BIOLOGICAL CHEMISTRY HOPPE SEYLER	829.75
BIOLOGICAL CONSERVATION	830.00
BIOLOGY OF REPRODUCTION	160.00
BIOMETRICS	90.00
BIOMETRICA	124.00
BIOPHYSICAL JOURNAL	650.00
BIOSCIENCE	125.00
BIOTECHNIC AND HISTOCHEMISTRY	102.00

BIRD OBSERVER	16.00
BOTANICAL REVIEW	65.00
BRITISH MUSEUM NATURAL HISTORY BULLETIN BOTANY	125.71
BRITISH MUSEUM NATURAL HISTORY BULLETIN ENTOMOLOGY	123.67
BRITISH MUSEUM NATURAL HISTORY BULLETIN ZOOLOGY	125.71
CAMBRIDGE PHILOSOPHICAL SOCIETY BIOLOGICAL REVIEWS	133.00
CANADIAN JOURNAL OF BOTANY	367.00
CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES	360.00
CANADIAN JOURNAL OF MICROBIOLOGY	258.00
CANADIAN JOURNAL OF ZOOLOGY	401.00
CELL	340.00
CELLULAR IMMUNOLOGY	1,120.00
COLONIAL WATERBIRD SOCIETY	45.00
CONDOR	60.00
CONSERVATION BIOLOGY	175.00
COPEIA	90.00
DEVELOPMENT	1,250.00
DEVELOPMENT GROWTH AND DIFFERENTIATION	212.00
DEVELOPMENTAL BIOLOGY	1,539.00
DIFFERENTIATION	999.00
DIVERSITY	55.00
ECOLOGICAL APPLICATIONS	75.00
ECOLOGICAL MONOGRAPHS	45.00
ECOLOGISTS	78.00
ECOLOGY	210.00
ECONOMIC BOTANY	70.00
EMBO JOURNAL	695.00
ENDOCRINE REVIEWS	110.00
ENVIRONMENTAL ENTOMOLOGY	150.00
ESTUARIES	185.00
ETHOLOGY AND SOCIOBIOLOGY	324.00
EVOLUTION	160.00
EXPERIMENTAL CELL RESEARCH	1,380.00
FEBS LETTERS	3,167.00
FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY JOURNAL	275.00
FEMS MICROBIOLOGY	3,501.00

FUNCTIONAL ECOLOGY	303.00
GENETICA	429.16
GENETICS	270.00
HEREDITAS	167.31
HEREDITY	295.00
IBIS	180.00
ICES JOURNAL OF MARINE SCIENCE	177.00
IMMUNOLOGY AND CELL BIOLOGY	215.00
IN VITRO CELLULAR AND DEVELOPMENTAL BIOLOGY. ANIMAL	300.00
INSECT BIOCHEMISTRY AND MOLECULAR BIOLOGY	780.00
INTERNATIONAL JOURNAL OF BIOCHEMISTRY	1,240.00
INTERNATIONAL JOURNAL OF PLANT SCIENCES	145.00
INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE AND NATURAL RESOURCES	55.00
JMBA JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION	345.00
JOURNAL OF ANIMAL ECOLOGY	303.00
JOURNAL OF APPLIED ECOLOGY	303.00
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