INFORMATION-SEEKING HABITS OF ENVIRONMENTAL SCIENTISTS: A STUDY OF INTERDISCIPLINARY SCIENTISTS AT THE U.S. ENVIRONMENTAL PROTECTION AGENCY IN RESEARCH TRIANGLE PARK, NORTH CAROLINA

by
Janet Murphy

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This study describes a questionnaire survey of interdisciplinary scientists conducting research at the U.S. Environmental Protection Agency in Research Triangle Park, North Carolina. The survey was conducted in order to gain a clearer picture of how the interdisciplinary scientists seeks information, and in particular how the interdisciplinary scientist manages his/her time in regard to information-gathering tasks.

Researchers at the Environmental Protection Agency report that they have some difficulty in maintaining a vocabulary in several scientific disciplines at the same time. Results also indicate that while scientists are utilizing the assistance of others in information-gathering, they do not report a heavy reliance on library resources. Analysis of the current status of the researchers' needs shows that researchers are demonstrating an increasing need for assistance in information-gathering.

Headings:

Information needs – Environmental scientists

Information services – Special subjects – Environmental scientists

Surveys – Information needs

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INTRODUCTION

Few studies have been done in the area of information-gathering practices of interdisciplinary scientists. The recent literature of library and information science, while concerned with improving access and use of information, tends to focus more on emerging electronic services than exploring existing needs. There is a small body of literature on the needs of scientists, but the articles tend to focus on specific scientists—biologists, chemists, physicists-- and tend to have been written between 5 and 15 years ago. While these articles are relevant to interdisciplinary sciences, they do not take into account the special needs of the researcher undertaking research in several disciplines or the researcher who needs to be fluent in several sciences in order to conduct his or her research effectively. These articles also have not been written recently enough to take into account the effect that technology has had over the last five years in terms of research habits and needs of the interdisciplinary scientist.

The sciences have exploded in recent years, branching off into innumerable specialties—geochemistry, toxicology, biochemistry are just a few. Many undergraduate and graduate education al programs are now offering majors and minors in concentrations that require in-depth knowledge of at least two of the major scientific disciplines. More and more, as research projects expand, there is a need for scientists to keep current in not only their own major field of study (if those areas can be neatly categorized into one discipline) but in at least one other field.

If a researcher is doing his or her job effectively, a certain level of awareness of general scientific trends is required. Environmental scientists, whatever their main specialty, are generally expected to keep current in all facets of science which effect the environment. A biologist who studies the health effects of toxins on the human body would be expected to possess a certain level of knowledge about what is going on in the fields of medicine, chemistry, geology, etc. The researcher would also be expected to keep current on emerging trends in "popular" science in order to be well informed.

The small body of literature expresses the main difficulties researchers tend to have in keeping current in their own parent discipline. Little to nothing has been written to contemplate how interdisciplinary scientists manage to gather and use information from several disciplines. The literature available on information-gathering of scientists is a bit out of date and does not yet fully explore the effects of the electronic information world on the scientist's information-gathering and use. This information is crucial to developing new initiatives in science libraries.

The goal of this research project is to uncover how interdisciplinary researchers gather and use information, and explore how technology has changed information-gathering habits in recent years. It is hoped that recommendations can be made to support and enhance effective research.

LITERATURE REVIEW

The literature of library and information science, education and management give little reference to interdisciplinary science research. The habits of scientists, while important, tend only to be studied within the confines of a defined discipline. While this is important research, interdisciplinary studies cannot be ignored. Palmer demonstrates the growing need:

> User studies within library and information science have provided important insights into the information-seeking behavior of researchers, but the groups studies have generally been discipline based…These studies have offered sufficient evidence that cross-disciplinary inquiry is practiced to a significant degree. We know little, however, about how discipline-crossing research is conducted or about how information is used in the process. (Palmer, 166)

Palmer's 1996 article outlines the growing trend of interdependence across scientific disciplines and the lack of literature on the needs of those performing the research. The general trends of geoscientists, medical researchers, physicists, chemists and engineers can be used as a starting point for further research. It can be inferred that some trends will carry over from one discipline to another due to their unity under the umbrella heading of "science".

Some trends seem universal to all scientific researchers. The literature to this point suggests that scientists, in general, tend to rely on personal networks for information. Conferences, colloquia and personal interactions are generally highly ranked by scientific researchers in their primary habits of information-gathering habits throughout the literature:

> For researchers…personal networks are the most important vehicle for information exchange. Colleagues and students are rich sources of information because they are efficient and yield quality results…Researchers consult with contacts from different backgrounds to explore the various ways a problem can

> be approached, to grasp the long-term hopes for a solution, and to learn how their research relates to other work on the problem. (Palmer, 170-171)

Many scientists rely on graduate students to gather information, as well as their fellow researchers. It can easily be argued that personal networks play a more significant part in the world of the researcher than print resources. There seems to be a "grapevine" within each of the sciences which is responsible for disseminating current research information:

> Certain people serve as conduits, enhancing the exchange of information by learning, filtering, analyzing, and making intellectual connections for the scientists. They function as transfer mechanisms or intermediaries between scientific communities. An intermediary may bridge the work of two different labs, act as a carrier of knowledge between academic research and industry, or provide the link between experimentation and theory…this unique research function is most often allotted to graduate students. (Palmer, 179)

Informal means of information-gathering are beneficial to scientists as they are a time-saving means of research, however there are inherent flaws involved with gathering scientific information through personal networks. What if one has no graduate student to rely on for accurate information? What if one has no contacts in the scientific community from which to elicit information? Large gaps in the gathering of information occur when one relies only on word of mouth. Informally gathered information is also inherently unreliable, even when gathered from "reliable" sources. Scientific research must be based on truth and evidence, not on conversations. While personal contacts provide inspiration and new ideas to researchers they are not necessarily facts, and cannot be used as a basis for research studies.

In addition to collecting information on an informal level, the literature highlights the inherent difficulties involved in gathering information through more formal channels, such as published journal articles. Many times, the reader of a scientific

journal must have a certain mastery of the terminology of several given disciplines. "For example, the bionicist who scans branch abstract journals devoted to the biological sciences will have to guess for himself which papers will be of interest to him" (Pachevsky, 120) The interdisciplinary researcher is saddled by a particularly heavy burden:

> The more subject areas a scientist spans, the greater the burden, and the work is especially taxing because the researchers are not just responsible for specifics that are borrowed from another field. They must also understand the history, surrounding context, and the current status of material. (Palmer, 176)

Because the burden of keeping this knowledge at one's command, interdisciplinary scientists tend to rely more heavily on personal contacts to compensate for the fact that they do not have the time or energy to spend on the literature. The interdisciplinary researcher, because he or she must master more material often winds up *reading* less and *scanning* more:

> Broad reading can help maintain a cross-disciplinary edge and sustain a wide perspective…However, researchers who read broadly do not necessarily read carefully. Some recall a time when they had been able to read entire articles and some journals cover to cover on a regular basis. Now documents are usually skimmed than read. (Palmer, 174)

We can draw from each of the disciplines, and construct a framework for what the interdisciplinary researcher must master. Any interdisciplinary researcher must master an extensive vocabulary in two or more areas of study. To do this well, most researchers rely on personal contacts, graduate students and a scanning of the literature. In order to learn about specifics of each discipline, one must explore them one by one.

In a 1989 study of geoscientists, Bichteler and Ward's research found that geoscientists depend heavily on journals and personal contacts. The study found that

geoscientist were less interested in end-user searching and were generally frustrated by foreign language literature. This particular study split geoscientists up into categories within geoscience: geochemists, geophysicists, engineering geologists, hydrologists, hydrogeologists and found that certain habits were found amongst all geoscientists. Geoscients spend two to ten hours per week in information-seeking activity. The lion's share of their information-seeking emanates from professional contacts (colleagues, conventions, correspondence), home or office journal subscriptions, book collections and bibliographic databases. Library and information centers are used primarily for browsing new journals, new book announcements, bibliographic databases, and asking librarians questions directly (170).

Geoscientists are idiosyncratic in that the body of journals they need to master can go back one hundred years, easily. Geological structures do not change dramatically, and the same structure might only be studied once in a hundred year period. History of a geological area is very important to its present state. Unlike in the medical profession, geological surveys and periodicals are still relevant to researching geologists today. For instance, a geologist conducting a survey of a geographical area needs to gather every bit of information regarding previous surveys, maps, photographs, etc. to do a complete assessment of a given area. Libraries that serve geoscientists need to maintain large map collections, significant serials collections and a reasonable amount of monographs in order to support adequate research. What is not present in the literature is the fact that more and more, the geological sciences library must be able to support GIS (Geographic Information Service) technology and if possible their own mapping computer programs

in order to keep up to speed with the United States Geological Survey and to stay competitive with other research centers.

Allen, in a 1991 study of the scientific communication in the realm of physics information, expresses some similar findings. Although the ultimate goal of Allen's article is to explore how electronic communications have impacted scientific communication among physicists, he makes some basic habits clear. Oral communication among researchers is a key method of finding information. Physicists also rely heavily on written communication. Allen outlines more specifically the kinds of written works that are most significant to physicists :

> Types of formal written communication in physics are the refereed journal, preprint, monograph, conference proceedings, technical report, dissertation or thesis, popular journal, newsletter and abstracting journal. The most accepted type of publication within the scientific community is the refereed journal. (Allen, 29)

Allen makes his point that oral communication is paramount to physicists in information-gathering; the refereed journal plays a significant role in disseminating new ideas and streamlining the research process. While all journal literature is significant, refereed journals have already been screened and "approved" by researchers in the field. This article stresses the importance of gathering information by physicists from all journals as well as conference proceedings and dissertations.

A literature review on the use of information resources by health professionals emphasizes some similar points. Osiobe asserts in his 1985 work:

> The application of the knowledge of other disciplines to medical practice has increased the body of information resources health professionals must deal with if they are to keep abreast of developments in the frontiers of their calling. The dissemination of new medical information and incorporation of research findings

> into practice by health professionals are major challenges in the field of medicine. (Osiobe, 965)

Keeping in mind that Osiobe's work was compiled well before electronic mail and the internet were commonplace tools in the workplace, his findings are still relevant. He points out that the major trends in medical research and practice tend to be: "person-to-person communication…[and] formal channels such as scholarly and bibliographic publications." (Osiobe, 965) In Osiobe's literature review, he gathers together the common methods of medical information-gathering from earlier years. He points out that medical researchers, while communicating in some ways similar to other scientists, have their own idiosyncrasies in gathering and using information. Psychiatrists, for example, tend to rely more heavily on informal sources for information, while surgeons relied more heavily on the printed word. (Osiobe, 965-66). For health professionals, each specialty has developed its own information-gathering practices, for better or worse.

Libraries that support medical research bear a heavy burden in that medical research changes so rapidly that only the most up-to-date information is acceptable. Older medical research, while important, is not what medical researchers need most. Medical research libraries must keep up sometimes very expensive journal subscriptions just to keep their users aware of current trends in medicine. It is also imperative for medical researchers to have access to medical databases such as MEDLINE, a tool produced by the National Library of Medicine. While PubMed is now provided as a free service of NLM, due to its complex controlled vocabulary system, it remains a difficult source for researchers to use efficiently—especially ones who do not consider medicine

their parent discipline. Medical libraries need to provide searches for their researchers and/or provide instruction on finding information in the database.

Engineers, finally, are a similar but distinct kind of scientist. Pinelli asserts in his 1991 article that: "Information professionals have assumed certain similarities between science and technology and scientists and engineers." (Pinelli, 5) Several works have been written in the last 10 years on the information-seeking habits of engineers, engineer/scientists, and engineering students. Although Pinelli points out that engineers are more involved with the extroverted research of solving problems than the introverted research of general scientists, his points illustrate some similarities. Engineers tend to utilize informal means of communication, and tend to work either alone or closely with colleagues rather than working with the literature. Engineers tend to rely on the literature less, and tend to shy away from journals alltogether. Engineers, as a group tend to rely more on handbooks, standards, specifications and technical reports (Pinelli, 13). The article also points out that these information-seeking habits will vary as to what kind of engineer is doing the research.

Hertzum and Pejtersen, in a more recent work on the information-seeking habits of engineers, state openly that "engineers search for documents to find people, search for people to get documents, and interact socially to get information without engaging in explicit searches." (Hertzum, 761) The articles suggests that engineers do search for literature, but the main goal is to find a knowledgeable person with whom they might talk about their own project. While engineers are a unique group of individuals centered on problem solving and design, their habits lean towards oral communication, much like chemists, biologists, geoscientists, etc. While engineering is regarded as a more applied

than theoretical discipline, engineers are full-fledged members of the scientific information-seeking population. As the "pure" disciplines merge and combine, more emphasis is placed on a marriage between the theoretical and applied sciences.

The literature to this point suggests that while scientists have their own needs, most rely heavily on personal contacts, conventions and current literature. Almost all articles written on these habits explore the flaws with these practices, such as insecure or insufficient information, and the difficulty in finding the appropriate information for their research. Written communication such as the journal literature plays an important part in scientific research. However it also has its flaws. Many scientists find that they do not have the time to keep current in their field of interest. They do not feel that they have the time to spend time in the library searching for information. The volume of published articles is just too high. What is a scientist to do when it is necessary to keep current on at least two scientific fronts?

The literature on interdisciplinary research concerns itself with filling in the gaps for researchers who feel they need to spend their time keeping current in more than one discipline to do their research effectively. One problem with cross-disciplinary work is that there is somewhat of a language barrier between the sciences. A researcher must sometimes master an entire new vocabulary within two fields in order to understand the literature. Carole Palmer, in her article on the boundaries of sciences and library services explains that "Experienced researchers feel like novices as they look for information in unfamiliar contexts and attempt to become oriented and knowledgeable" (Palmer, 170) As different disciplines use different sources for collecting information, a master in one discipline might be completely lost as to begin research in another area. For instance, if a

chemist has found certain journals and databases useful and sufficient in his/her research, but one day needs to add more engineering research to the process, that individual is lost. How is the chemist to know about patent searching, trade manuals and personal networks in engineering?

Another barrier to collecting relevant information is the time factor. The process of searching for information across disciplines with differing vocabularies is difficult enough. Sorting through that information for relevancy is another project. "Researchers who do a lot of information probing are frequently faced with the task of sifting and evaluating all the ideas and 'pet theories' that they come across. (Palmer,171) These researchers wind up spending more time skimming the vast volumes of literature instead of focusing on the more relevant articles. As many researchers find it useful to network with other researchers in their field, they find it doubly difficult to do when researching several disciplines at once.

It is interesting to note that a study done by Julie M. Hurd in 1992 noted that in her sample group of professors in a university chemistry department :

> Less than 60 percent of the sample articles authored by chemistry department faculty were published in journals that Ulrich's classifies as chemistry…When citing journals outside their own primary field, these scientists appeared to make most use of journals in physics and biology, but also occasionally cited materials in a number of other fields. (289)

This information is noteworthy in that it shows that scientists must move towards an interdisciplinary way of collecting and using information. The articles that are being written today require a vast knowledge of all forms of science.

So how have interdisciplinary researchers and librarians found information over the years? Librarians have been concerned not with mastering all of the changing

information trends in the fields but in connecting people with the "edges" of information needs. It has been established that scientists and engineers have specific information-seeking needs. Librarians have not established firm ideas for providing optimum services for this group. However, from the literature, it is clear that more bibliographic instruction is needed, and more training for scientists in making effective use of library tools.

The most current cry from researchers is for more databases and full-text articles to be delivered to the desktop. The literature on information-seeking habits of scientists, while informative, is dated. Little of the literature mentioned above addresses the impact of electronic mail, document delivery, electronic indexes and databases, electronic journals, and the world wide web have had on scientific research and communication. The quote below illustrates the attitude of most scientific researchers toward older research:

> …the literature used by scientists is markedly biased in favour of recent publications. In terms of reading habits this means that scientists will more often than not be found reading recent issues of journals. A survey of scientists in a U. S. Federal laboratory showed that over 80 per cent of the material they read had appeared within the previous twelve months, and over half of all the reading they did was of journals that had just been published…(104)

As more literature is being written in the library and information science journals on the effect of the electronic world on library services, librarians are beginning to gain a clearer view of their placement in information-seeking and reference services.

METHODOLOGY

The goal of this research project is to gain a clearer view of the information-seeking habits of the environmental scientist than has been presented in the literature of the last 20 years. In order to re-evaluate services to this increasing population, it is necessary to observe what the current habits are for information-collecting and use. In order to begin an adequate collection of this information, a sample set of researchers at the Environmental Protection Agency (EPA) in Research Triangle Park, North Carolina, were selected to represent a wide variety of disciplines. The sample set of subjects emanate from several of the largest labs on the EPA campus. A written cover letter and survey (see Appendices A and B) were distributed to a convenience sample of a total of 269 researchers involved in a wide range of research in order to uncover ideas about how researchers use and view their time use and commitment to keeping current in the sciences; what tools and sources they are utilizing; what their current needs are and to get an idea of the future needs of the EPA research community.

The methodology for accomplishing this task was to ask this sample set of researchers to complete a short survey that addressed the ideas expressed above. The survey consisted of some basic questions about the participant's educational background and training, and primary field of research. The survey then asked the researchers to identify any secondary or tertiary field of study in which he/she conducts research. After the basic information, there are some open-ended questions addressing how respondents feel their time could best be utilized, what sources they use for information-gathering and what sources/services they would like to see in the ERC (Environmental Research Center) library.

Due to the nature of the EPA's contract, contractors (such as the author, the library director, etc.) cannot distribute information en mass to federal employees. Therefore, in order to determine a select group of researchers to whom the survey might be distributed, the author and library director enlisted the help of the library project officer. Being a federal employee with allegiance to the library, he was able to make connections with several of the laboratory representatives in order to arrange to have the survey distributed. Representatives for several of the largest labs on the EPA campus selected which researchers would be eligible for the survey given their specific research duties. The names of these individuals were then supplied to the library project officer so that the author could distribute the survey to those selected individuals. The library director also supplied the author with a list of individuals who were already subscribed to the library's electronic newsletter.

RESULTS AND ANALYSIS

Out of the 269 surveys distributed, 149 were returned to the author. The selected individuals reside within various divisions/labs on the EPA campus, with various research subject specialties. Out of the 149 respondents, some omitted responses to specific questions on the survey, as is their right as participants in this research study.

The range of subject specialties of respondents was large, with many respondents indicating that either their current research or educational background involved interdisciplinary study. Although the researchers at the Research Triangle Park facility of the EPA primarily focus on the environmental effects of stationary air pollutants, there are a wide variety of research foci. The largest lab on the EPA campus concerns itself primarily with health effects of environmental air pollutants from stationary sources (e.g. industry). Some of the researchers in the other labs concern themselves also with the physical and other environmental effects of air pollutants from stationary sources. In addition, some researchers concentrate on research projects only tangentially related to environmental air pollution. The population of participants represents a truly interdisciplinary group.

Of the 147 participants who responded to the first question (see Appendix B, question 1), 63 different subject areas were identified as the primary educational discipline of the researchers' education. This would mean that amongst the 149 selected researchers, 2 omitted this question and 147 respondents identified 63 distinct areas of study as their primary educational pursuit. Toxicology (an interdisciplinary subject area) was the most heavily identified as a primary educational pursuit. Biology, Chemical Engineering, and Chemistry were also frequently identified as primary educational

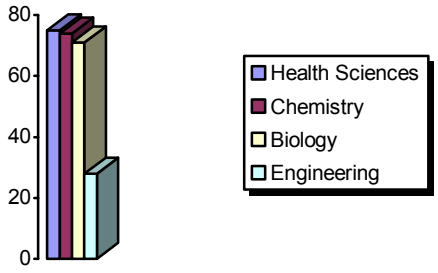
subject areas. The remainder of the responses was more or less evenly distributed amongst the other 58 disciplines reported with one researcher identifying with each subject area.

Out of the 147 respondents, approximately half of the respondents identified interdisciplinary subject areas as their primary educational background. These subject areas varied widely including Toxicology (as indicated above), Neuroscience, Pharmacology, Biostatistics, Environmental Health, Risk Management, etc. While the most popular educational subject specialty indicated was Toxicology, many subject areas were identified. Respondents reported a variety of subject areas, ranging greatly in expertise. From this, one can conclude that while approximately 50% of the respondents did their primary educational work in one of the established disciplines, (e.g. Biology, Physics) approximately 50% completed their educational training in a subject area identified as interdisciplinary. This would suggest that a significant number of researchers would indeed have had to master the terminology of at least two scientific fields of study even before beginning their professional research.

While indicating that their educational backgrounds included a wide range of both established disciplines and interdisciplinary subject areas, respondents overwhelmingly indicated that a sizable knowledge of other disciplines *was* required for them to conduct their own research. Out of 148 respondents to this questions (See Appendix B, question 2), all identified at least one additional discipline about which they needed to have a sizable knowledge in order to conduct their own research. The fields of Health Sciences, Chemistry, and Biology were the most highly identified as being necessary to the respondents' research. An additional 45 subject areas were added by respondents

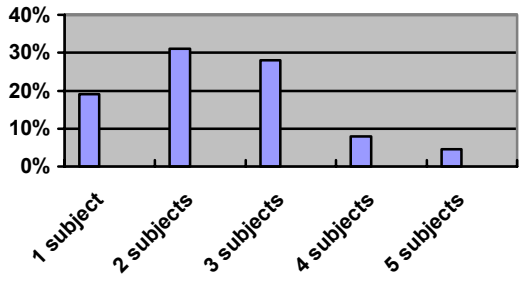
including subject areas such as Toxicology and Physics (See Appendix C). Again, although various subject areas were identified, most subject areas had only a handful of researchers identifying with each of them (e.g. Math, Biostatistics, Public Administration). Table 1 illustrates the most highly identified educational subject areas by EPA researchers.

Table 1—Subject areas essential to respondents' research



Out of the 148 participants who responded to this question (See Appendix B, question 2), most indicated that knowledge of more than one subject area was essential to conducting his/her own research. The results in Table 2 indicate that it is necessary for most of the respondents to have a sizable knowledge of 1-3 subject areas in order to conduct their own research. When asked to identify from the list of 5 major disciplines (e.g. Chemistry, Biology, Geology, Health Sciences, and Engineering), the bulk of respondents (73%) indicated more than one response, often writing in more specific areas of research with which they must be very familiar. It is clear that almost half of the respondents feel that they need to be very familiar with at least 3 different subject areas in order to conduct their own research.

Table 2: Number of subject areas identified as essential

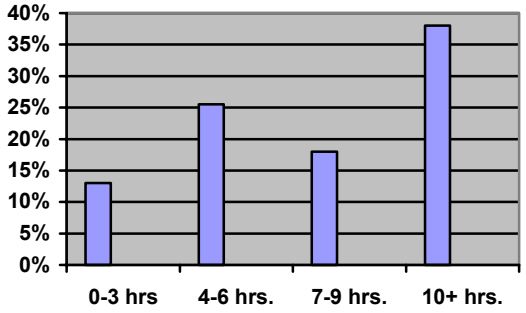


Additionally, 89% of respondents indicated that they needed to be somewhat or very familiar with the terminology of another discipline in order to understand the literature. Only about 4.5% of respondents indicated that they did not need an in-depth grasp of the terminology of another discipline in order to understand the literature. These findings not only confirm those of the researchers cited in the literature review, but also demonstrate that EPA researchers need to master a tremendous amount of resources in order to conduct their research successfully. Most feel that they need to be familiar with several subject areas as well as possess a fairly sizable vocabulary in other disciplines just to be able to understand the literature.

When respondents to the survey were asked to indicate how many hours he/she spent in a typical week on information-gathering, a wide range of responses were indicated. The bulk of respondents fell within the range of 4-10 hours per week. Table 3 indicates that the largest portion of respondents identify themselves as spending 10 or more hours per week in information-gathering pursuits with most respondents indicating that they spend at least 4 hours per week in information-gathering. This confirms that

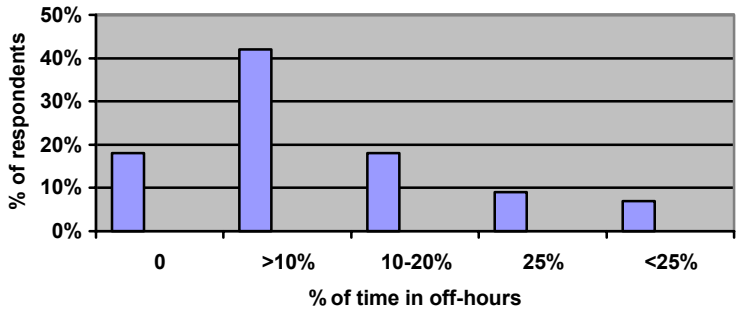
information-gathering plays an important role in the day-to-day research of an EPA researcher.

Table 3: Hours spent per week in information-gathering



Out of the 149 respondents who indicated the amount of time spent in information gathering, 85% indicated spending anywhere between 10% and 25% of their off-hours (e.g. personal time) in this pursuit. Table 4 illustrates the fact that most respondents devote some amount of their off-hours in information gathering for their research at the EPA. While most respondents indicate that they perform approximately 10%-25% of their information-gathering in off-hours, only 19% indicate that they achieve all of their information-gathering during work hours.

Table 4: Percentage of off-hours used in information-gathering



When respondents were asked to characterize how they *feel* about the time required for information-gathering, approximately 85% of respondents indicated that they at least had some trouble keeping up with everything they would like to in regard to information-gathering. Only about 11% of respondents indicated having no trouble at all in regard to keeping up with everything they'd like.

One can conclude that most EPA researchers, regardless of research area, feel that they need to be familiar with several subject areas in order to conduct their own research. In addition, respondents indicate strongly that there is much more information-gathering to do than they are able, so much so that many conduct up to 25% of their information-gathering on their own time. It can be assumed that work hours not devoted to information-gathering are devoted to duties such as conducting experiments, attending meetings, etc. So, if one assumes that the researcher devotes the largest portion of his/her time to other duties, it leaves precious little time during the workweek to seek out relevant information in their field(s) of research. It seems clear that, based on the results of this survey, that EPA researchers could use some assistance in keeping up with the massive amounts of information available. If researchers feel that they must have a sizable knowledge of several disciplines with a significant amount of terminology to master in each, how do they manage to keep up with scientific trends?

One answer to this question is that researchers utilize the help of others in their information-gathering. For the most part, respondents indicated that they relied most heavily on support staff for their information-gathering assistance. Graduate students and other contractors were cited as being instrumental to the information-gathering pursuits of most respondents. However, these same respondents indicated above that they needed

to master several subject disciplines and overwhelmingly indicated that they needed to master a sizable vocabulary to understand the literature. So, how can others assist in information-gathering pursuits? Some graduate students would be able to assist in information-gathering for the researcher due to their education in at least one scientific discipline. However, support staff and contractors would not generally have the educational background or training to evaluate or interpret literature or scientific trends.

For the most part, respondents indicated that they utilized others mostly in the function of photocopying articles. Theoretically, the researcher would identify which articles he/she needed to obtain and then send a contractor, support staff member or graduate student off to do the photocopying. The researcher would then be able to read the article(s) and interpret the ideas. However, many respondents also indicated using others for such activities as searching for relevant articles, learning about current trends in the field(s) of interest, verifying facts and synthesizing scientific information into reports. It is interesting to note that approximately 15% (22 total respondents) out of 149 omitted this question (See Appendix B, question 9).

Table 5: Capacity in which help is utilized

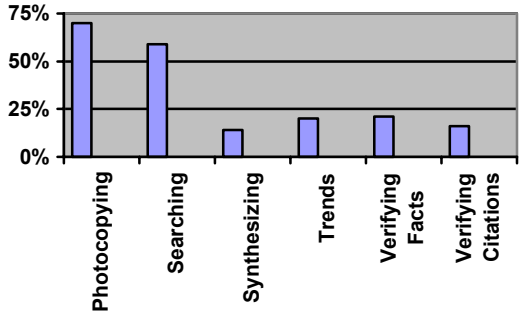


Table 5 illustrates that respondents rely on others to—at least some of the time—interpret the terminology of other disciplines, search effectively for relevant information, and understand the literature well enough to learn about trends and synthesize this information into reports. This indicates that at least some of the information-gathering is being passed on to individuals who may or may not have the training to conduct it efficiently. This reliance on others for information-gathering, perhaps due to the massive amounts of available material, could cause serious problems if it increases. If support staff and contractors are required in the future to interpret articles in subject areas about which they have insufficient training, the work of the researcher could be compromised if strict oversight is not employed. However, if the researcher does not have the time to conduct his/her information-gathering in a typical week will the research be compromised anyway? It is clear that EPA researchers are finding that they can utilize the help of others in order to gather information and sometimes search for, interpret and digest it. In addition to these regular sources of assistance, the EPA library is available 24 hours per day for the researcher's convenience.

When respondents were asked to characterize how often they requested assistance with information-gathering, approximately 63% of respondents indicated that they seldom asked for assistance. Only about 22% of respondents admitted that they requested assistance on a regular basis or very often. About 9% of respondents indicated that they never asked for assistance (see Table 6). Several indicated with comments that this assistance most frequently emanated from requesting reprints or photocopies of articles. So, there is a slight discrepancy in the responses. On the one hand, researchers are

indicating that they—for the most part—do not ask for assistance in information-gathering. On the other, researchers are indicating that they do in fact enlist the help of support staff, contractors and graduate students in these pursuits—sometimes even to understand and interpret complex scientific ideas. Table 6 demonstrates the frequency of the respondents' requests for assistance. Further research would be needed in order to gauge a better understanding of the discrepancy in the participants' responses.

Table 6: How often respondents request assistance

For the most part, respondents indicate that they have at least some trouble keeping up with all of the relevant scientific research but most claim not to request assistance with this pursuit. When others are utilized in information-gathering, those who are called to assist are generally contractors and support staff—individuals who are generally not trained in information-gathering. It seems that respondents feel that although they do not ask for assistance with information-seeking pursuits, they do ask for assistance at least some of the time. When respondents do ask for assistance, it mostly comes in the form of photocopying but sometimes also in the forms of searching for relevant information, synthesizing it into reports, learning about current trends, verifying facts and verifying citations.

It is clear that large amounts of scientific information are becoming available via the Internet and the World Wide Web. When respondents were asked if electronic resources made it easier or more difficult to gather information, the largest portion of respondents indicated that having access to electronic information made information-gathering easier. Very few (about 6.5%) indicated that having access to electronic resources actually made information-gathering more difficult or much more difficult. These last responses may explain why researchers are sometimes utilizing support staff, contractors and graduate students in their information-gathering pursuits. Theoretically, if the respondents feel that relevant scientific information is easier to find than it was several years ago, then perhaps researchers feel that they can leave that part of the information-gathering to others so that they have more time for other necessary duties.

When asked how electronic dissemination of information affected their information-gathering habits in the last five years, about half of respondents indicated that their habits were very different now from what they were five years ago. The other half of the respondents either stated that their habits were roughly the same or made comments without indicating an answer. A large number of the comments reflected those of one of the researchers when he or she stated "Electronic access to journals makes it much easier and faster, but there's still no substitute for the article itself." This may help to explain how and why researchers are utilizing others in their information-gathering. Although these results reinforce the points made in the research presented in the literature review on the information-seeking habits of scientists, it still leaves the question of why researchers are not significantly requesting the assistance of librarians for information-gathering.

Indeed, why aren't researchers even utilizing library resources? Only a little more than half of the respondents (79 out of 147 respondents) expressed that they used the ERC library's resources on a regular basis. A smaller portion indicated that they used library resources either rarely or never. Only about 9% (13 out of 147 respondents) reported that they used the library's resources on a frequent basis. How are researchers obtaining the relevant scientific information without using the library's resources? Part of the answer to this question may lie in the results from the rest of the survey.

When respondents were asked to indicate which resources were most relevant to their work (see Appendix B, question 10), the most highly cited resources were other experts in their field(s) of study. As the literature review highlights, scientists prefer to confer with other experts than to actually search for information in a database or ask a non-scientist for help. The majority of respondents indicated that their most relevant resources were derived from conversations with co-workers (fellow scientists) and other experts, e-mailing and attending conferences. A large portion indicated that reading articles and books—a solitary pursuit—composed a significant part of their relevant research. Although many indicated that reading articles was highly relevant, few rated reading *electronic* journal articles as highly relevant. In opposition to the information presented in the literature review, EPA researchers rated scanning citations as somewhat less relevant to their overall work. Interestingly enough, respondents indicated that reading e-mail alerts and participating in discussion lists were amongst the least relevant of the information resources. (Note: approximately 40% of respondents either omitted this question or answered in a format contrary to direction. Most indicated more than one source as appropriate.)

It is interesting to find that although electronic resources are available in higher volume than ever before, respondents to this survey indicated that the most heavily used resources are still print journals. Although researchers indicate that electronic databases are heavily used for finding these articles, they are still reliant on the paper version. While several researchers indicated that technical reports were important, they were not heavily relied upon, either in print or electronic form. One researcher comments on this phenomenon: "It is evolving so rapidly that printed material will be used less and less—e.g. will book and journals still be available in print form in 10 years?" Another researcher reflects, "I use databases extensively but I don't like reading articles online. I print them or copy them from print resources." (Note: approximately 40% of respondents either omitted this question or answered contrary to direction.)

Table 7: Most/Least heavily used sources

Whatever the reason for reliance on print resources, it is interesting to see what researchers actually desire from their library. An overwhelming amount of respondents took the time to make comments either on the present state of library services or to make suggestions regarding future services. An overwhelming number of those who make comments not only requested but also nearly demanded that electronic resources be

improved in their area of expertise. One researcher sums up these requests by stating simply "More access to electronic journals". Many respondents made specific requests for certain electronic journals to be provided, indicating that they have been paying for subscriptions on their own. A researcher requests "Better choices of journals and more EPA licensed electronic journal subscriptions." A provocative question that can be drawn out of these responses is this: Are the EPA researchers relying on print resources because they are indeed the most authoritative sources of information or because the library does not yet provide adequate access to electronic resources? Would researchers in fact depend on these electronic resources if they became available? Do researchers actually know how to use electronic resources efficiently enough to make good use of as well as depend on them?

In addition to the high number of requests for electronic resources, many respondents actually requested services that the library already provides such as providing reprint requests, specific journals and databases to which the library already subscribes. When respondents were asked which non-library supplied resources they used most frequently in their research (see Appendix B, question 11) a large number of respondents (about 55%) indicated that PubMed was the research tool of choice. A smaller but significant number of respondents indicated their fondness of general search engines/search directories such as Yahoo, Google and Alta Vista (all general search engines as opposed to scientific search tools). However, an alarming amount of respondents indicated a preference for tools such as Current Contents, ScienceDirect and Science Citation Index—all of which are supplied through the library's website. (Note: Many respondents provided more than one answer as appropriate.) It seems that

researchers are unaware that the library is actually supplying some of the resources they use already. This may account for the low number of respondents who claim to use the library. At least some of these researchers may be using the library's resources without knowing it. Because some of these resources (ScienceDirect, for example) can be accessed via subscription without actually going through the library's web site and others are not heavily labeled as "library-supplied resources" per se, researchers may be using library-supplied sources without realizing that the library has supplied them. This response also suggests that researchers are leaning towards using general internet search engines and not towards using search engines with a specific subject emphasis. Very few respondents actually indicated that they used a topic-specific science search engine as a part of their information-gathering.

In order to support efficient use of electronic resources, the EPA-ERC library currently provides a library instruction program. Online tutorials have been created by library staff members to train researchers on various scientific research tools. These tutorials reside on the EPA-RTP intranet and are available to researchers from their desktop. Included in this offering are courses on PubMed, InfoScout (an internal database provided by the Dialog corporation which allows users to search multiple science databases simultaneously), ScienceDirect (a searchable and browsable conglomeration of electronic science journals), general internet searching and Scientific internet searching (providing a number of science search engines, directories, etc.). These courses are not only housed on the EPA-RTP library website, they are taught as training classes on a quarterly basis by library staff members. It is interesting to note that although researchers are requesting more electronic resources, attendance at the training

classes is very low. Part of this is due to restrictions placed on the EPA's contract. Library staff members are not allowed to publicize class offerings to EPA researchers as a whole. Therefore, the library has to rely on contacting researchers in the immediate vicinity of the library and by contacting researchers who are already subscribed to the library's newsletter. Not surprisingly, a notable number of respondents (28%) indicated that they had never been aware of the newsletter and many commented that they had no advance notice of classes being taught. The publicity factor undeniably relates to the large number of respondents who are unaware of library resources. If services are to evolve to meet the needs of the research community, it will be necessary for the library to seek out alternative means of marketing and publicity.

Another reasonable possibility of why attendance to the training classes is low in lieu of the demand for electronic resources is that researchers feel that they are already at a level above what the courses cover. Several researchers indicated with comments that "Nothing has been offered except at a level of which I am already above". So, it is clear that some researchers feel that the classes offered by the library are a level that is below their present ability. It may be in the library's best interest to add to its class offerings some courses on advanced searching techniques in certain areas of study. However, the problem persists: how does the library provide advanced training for each of the subject areas on which researchers concentrate at the EPA? Because the library serves such a diverse community with such specific individual needs, it would be almost impossible to provide a class on each. In any event, researchers are generally not participating in the library's class offerings provided at the present time. Although many researchers feel that they are above the level of instruction, low attendance shows that they are not

sending the contractors, support staff and graduate students who assist them to the classes either. The low attendance is probably a combination of the above factors with the high probability that many researchers are not aware of library services available to them.

A large part of the problem the EPA-ERC library faces is that, due to contract restrictions, EPA staff members are extremely limited in the amount of marketing they are allowed to do for library services. As indicated earlier, the library will eventually have to solve this problem in order to contact the community that it is intended to serve. EPA researchers, to some degree, have indicated that they are unaware of the library's offerings. Because the library staff is aware of this problem, the survey asks respondents about how the library could best keep abreast of the researchers' changing information needs. The answers to this question were divided into two camps. Members of one camp reported thinking that the library is doing an excellent job and should continue on with service as it is. One respondent bearing this viewpoint comments that the best way for the library to keep up with the researcher's changing needs would be: "for me to go talk to someone of course. There are too many of us out here for you to come to us and individual needs would bog you down". Another comments, "Many of use are specialists. The researcher should take the initiative to inform the library. Otherwise, the library will not know what support to provide." The members of this camp generally acknowledge that the best way for the library to keep abreast of their needs is for the researcher to contact the library directly. Some researchers suggest that librarians could perhaps establish some liaisons in each lab and perhaps even attend lab meetings to gather the information directly. Still others holding this view suggest having a more

interactive website, allowing researchers to submit requests, make suggestions, etc. (again, a service which the library already provides).

The second camp takes a different stance, requesting extended service of the library. Several suggestions were made for the library to extend services such as this one:

> "If the library could maintain a database of the key search words that I have used, and inform me by e-mail when a new source becomes available, it could help. They should leave the decision to me as to whether that is still a research interest, or has become passé. Outdated research words should become inactive when I want them to. New words should be accepted for use at all times." (Anonymous respondent)

It is clear that there is a division amongst researchers on this topic. On the one side, there are researchers who feel that it is their responsibility to communicate with the library when they require assistance. On the other, there seems to be a demand for highly customized service for each individual. It is unclear what the best course of action is for the EPA library. In any event, users need to be informed of what services are available to them in order to use them efficiently.

The library may be able to explore some of the suggestions made by respondents in part by examining their website, perhaps making it more visible to researchers and/or strengthening the ties between library staff and each laboratory on the EPA campus. The library may additionally be able to negotiate some other forms of visibility to the researchers within the ERC facility.

It seems obvious that EPA researchers on the whole are significantly interested in seeing more electronic resources, e-mail alerts and interactive tools. One researcher comments at the conclusion of the survey that "I think you should be mailing these in smaller envelopes—or better yet electronically." This may be a reflection of current

trends in mainstream society towards integration of electronic resources into the workplace. EPA researchers are obviously utilizing more electronic resources to find information than they did five years ago, but it is still unclear as to what the most authoritative sources are in the sciences. Further research will have to be undertaken in order to establish strong correlations between the amount of electronic resources available to EPA researchers and their frequency of use.

SUMMARY AND CONCLUSION

In accordance with the literature, this research project has identified that many interdisciplinary researchers at the EPA are in fact finding it difficult to maintain a vast body of knowledge in two or more scientific disciplines, and are requesting assistance in their information-gathering pursuits. A significant amount of information-gathering is being done during the researchers' off-time. While electronic resources might be making it easier and faster to locate relevant scientific information, many researchers are not fully aware of the resources available to them via the ERC library. While the scientists questioned did indicate that personal contacts were a valuable part of their information-gathering, they relied heavily on print resources. It is unclear to the author whether or not electronic resources provide the most relevant scientific information to the researcher or not. Most indicated that they would prefer to receive valuable information in electronic format and that in the future they would like to see more electronic journals and databases available to them at their desktop.

Many researchers were not aware of the library's newsletter or of the library's instruction program—some were even puzzled about why they had not received word about these services. Respondents suggest establishing classes on topics of specific interest to them and/or more advanced searching classes. A large portion of respondents made suggestions for resources that the library already supplies. This suggests that the library needs to look into responding not only to the researchers' demand for more electronic resources, but also to marketing these resources once available.

Further research will be required in order to draw definitive conclusions about how researchers are using electronic resources and which are the most valuable. Currently, at least some researchers are recruiting support staff and contractors in their information-gathering. It would be interesting to determine whether there was, in fact, a correlation between the amount of resources available on the internet and the amount of assistance researchers request. Further research would also be required in order to establish whether or not personal contacts and print resources remain among the most heavily used sources of information for environmental researchers at the Environmental Protection Agency.

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APPENDIX A: COVER LETTER

THE UNIVERSITY OF NORTH CAROLINA
AT
CHAPEL HILL
School of Information and Library Science Phone# (919) 962-8366 Fax# (919) 962-8071
The University of North Carolina at Chapel Hill CB# 3360, 100 Manning Hall Chapel Hill, N.C. 27599-3360

Student Project

Dear EPA Researcher:

My name is Janet Murphy. I am writing to you as a graduate student in the School of Information and Library Science at the University of North Carolina at Chapel Hill. I have been working as a student intern at the main EPA library in Research Triangle Park as part of a long-standing internship program established between UNC and the EPA that allows students to gain practical work experience in Library Science while pursuing a graduate degree.

I will be conducting research as part of my master's paper: "Information-seeking habits of environmental scientists" in partial fulfillment for my degree. The enclosed survey is designed to identify the major trends in the scientific research process. The purpose of the survey is to analyze library services according to the needs of the research scientist in order to provide the best possible service to the EPA community of researchers. I hope to include responses from approximately 300 EPA researchers in my master's paper.

The survey asks questions about your educational background, the discipline(s) in which you work, about how much time you typically spend in searching for information, and what aids you currently use to assist in this process. It is designed to take about 15-20 minutes to complete. The University of North Carolina's Internal Review Board for content has approved all questions. The Academic Affairs Institutional Review Board (AA-IRB) of the University of North Carolina at Chapel Hill has approved this study.

If you have any concerns about your rights as a participant in this study you may contact the Chair of the AA-IRB, Barbara Davis Goldman, at CB# 4100, 201 Bynum Hall, UNC-CH, Chapel Hill, NC 27599-4100, (919) 962-7761 email: aa-irb@unc.edu. Participation is this study is voluntary. As a participant you may choose not to answer specific questions. All information is completely anonymous and information collected from this survey will not be provided to any outside agencies.

If you have any concerns regarding the survey, please feel free to contact my academic advisor, Dr. Claudia Gollop, either by phone (919) 962-8362 or by email at gollop@ils.unc.edu or me. Hopefully, you will choose to participate. If so, please complete the enclosed survey and return it in the accompanying envelope by April 13, 2001. Thank you for your time. Your participation is appreciated.

Thank you,

Janet Murphy, Graduate Student
School of Information and Library Science
University of North Carolina at Chapel Hill
murph@ils.unc.edu, Murphy.Janet@epa.gov
(919) 960-5695, 1-0208

APPENDIX B: SURVEY

1. What is the primary discipline of your educational background? (For example: microbiology, physics)

_____

2. Please indicate which of these other disciplines you need to have a sizable knowledge of to do your own research. (Check all that apply)

- ❑ chemistry
- ❑ biology
- ❑ geology
- ❑ health sciences
- ❑ engineering
- ❑ other, please specify

_____

3. Please indicate the amount of time you spend per week in information-gathering activities. (For example: Reading e-mail alerts, scanning journals, photocopying, conferring with co-workers or other experts)

- ❑ 0-3 hrs.
- ❑ 4-6 hrs.
- ❑ 7-9 hrs.
- ❑ 10 or more hrs.

4. What percentage of this time accurately reflects the time spent outside of work hours in information-gathering? (For example: home or off-hours)

- ❑ 0 (I do all of my information-gathering at work.)
- ❑ less than 10%
- ❑ 10-20%
- ❑ 25%
- ❑ more than 25% (I spend a significant amount of my off-time in information-gathering activities.)

5. How do you feel about the amount of time you spend on information-gathering?

- ❑ There is not enough time to keep up with everything I'd like.
- ❑ I have no trouble managing my time in regards to information-gathering.
- ❑ I have some trouble managing my time in regards to information-gathering.

6. How familiar with the terminology of another discipline do you feel you have to be to understand its literature? (For example: If you are a biologist, how familiar should you be with the terminology of chemistry, physics or other disciplines?)

- ❑ Very familiar
- ❑ Somewhat familiar
- ❑ Not very familiar (I can understand and use articles without mastering new terms.)

7. Do electronic sources make it easier or more difficult to gather and use information?

- ❑ Easier (I have more time for other tasks.)
- ❑ About the same (I spend about the same amount of time on information-gathering with or without electronic sources.)
- ❑ More difficult (It takes more time to gather and sort through information.)
- ❑ Much more difficult (There is too much information for me to sort through efficiently.)

8. Do you utilize the help of others, such as graduate students, contractors or support staff, in your information-seeking? (Check all that apply)

- ❑ Graduate students
- ❑ Support staff
- ❑ Contractors
- ❑ Others, please describe_____
  _____

9. If so, in what capacity? (Check all that apply)

- ❑ Photocopying/Retrieval of articles
- ❑ Searching for relevant information using scientific databases
- ❑ Synthesizing scientific information into reports
- ❑ Learning about current trends in the field
- ❑ Verifying facts
- ❑ Verifying citations
- ❑ Other, please describe _____
  _____

10. Please rank the following 10 information-seeking habits you feel are relevant to your work. (1=most relevant, 10=least relevant)

_____ Conversing with co-workers or other experts located at EPA
_____ Conversing with experts located outside of EPA
_____ E-mailing co-workers or other experts
_____ Discussion lists/Listservs
_____ Reading e-mail alerts
_____ Scanning journal titles or citations
_____ Reading articles/books
_____ Attending conferences/colloquia/workshops
_____ Searching electronic databases
_____ Reading electronic journals

11. Please rank the most important/heavily used information sources. (1=most heavily used, 5=least used)

____ Print journals or books
____ Print technical reports
____ Online databases
____ Electronic journals
____ Online technical reports

12. How has electronic dissemination of information affected your information-gathering habits in the last five years?

- ❑ Very different (I use completely different sources than I did five years ago.)
- ❑ About the same (I still use the same sources as I did five years ago.)

Comments:_____
_____

13. How often would you say that you use library resources in the course of an average month?

- ❑ Very often (Daily)
- ❑ On a regular basis (Weekly or bi-weekly)
- ❑ Seldom (Around once per month)
- ❑ Never

14. How often would you say that you request assistance in information-gathering from library staff in an average month?

- ❑ Very often (Daily)
- ❑ On a regular basis (Weekly or bi-weekly)
- ❑ Seldom (Around once per month)
- ❑ Never

15. Which non-library supplied sources do you most often use? (For example, PubMed, Northern Light, Yahoo, etc.)

_____
_____

16. Do you subscribe to the monthly electronic newsletter "News from the ERC library"? (Check all that apply)

- ❑ Yes
- ❑ No
- ❑ I was not aware of the newsletter

17. Have you attended any of the instruction classes offered at the main EPA-RTP library?

❑ No, I have not attended any of the instruction classes.
❑ Yes, I have attended the following: (Check all that apply)

o Basic Internet
o Finding Science Information on the Web
o InfoScout
o ScienceDirect
o PubMed

18. Would you be interested in seeing more classes offered by the library staff? If so, please list below any topics that you would like to see covered.

❑ No, I am pleased by the current offering of classes.
❑ Yes, I would be interested in seeing more classes offered. Here are some suggestions for additional classes:

_____
_____

19. What would be the most effective way for the library to keep informed about your changing information needs? (For example: when you are working on a new project)

_____
_____

20. Are there additional services that you would like to see offered by the EPA-RTP library?

❑ No. I am satisfied with the library services as they are.
❑ Yes. Here are some suggestions for additional library services :

_____
_____

Thank you for completing this survey!

If the envelope is lost, please return your unsigned and completed survey to:

Janet Murphy, UNC Contractor Staff
U.S. EPA Library
MD-35
86 Alexander Drive
Research Triangle Park, NC 27711

If you are interested in obtaining a summary of this survey, please contact me at murph@ils.unc.edu or Murphy.Janet@epa.gov . The results of the survey will be tabulated and incorporated into my master's paper which will be available in the School of Information and Library Science at The University of North Carolina at Chapel Hill and in the main EPA-RTP library.

APPENDIX C: LIST OF SUBJECT SPECIALTIES IDENTIFIED AS ESSENTIAL

Anthropology
Atmospheric Sciences
Behavioral Psychology
Biochemistry
Biophysics
Biostatistics
Cell Biology
Civics
Climatology
Communicable Diseases
Computer Programming
Computer Science
Developmental Biology
Economics
Endocrinology
Environmental Economics
Environmental Effects
Environmental Engineering
Environmental Exposure
Environmental Policy
Environmental Science
Environmental Technology
Epidemiology
Immunology
Information Technology
Math
Materials Science
Mathematical Modeling
Meteorology
Molecular Biology
Neuroscience
Neurotoxicology
Pathology
Pharmacology
Physics
Physiology
Public Administration
Public Health
Public Policy
Pulmonary System
Risk Assessment
Soil Science
Statistics
Thermodynamics
Water Resources